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Toyoki Ono, Professor, Dr.

Hiroshi Niino, Professor, Dr.

Itsuo Kubo, Professor, Dr.

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A STUDY OF THE FISHING POWER OF THE PURSE SEINE FISHERY

Makoto Inoue

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I. Introduction

The purse seine fishery, which is a type of Round Haul Nets fishery, has occupied a very important position together with trawl fishery in the coastal and off-shore fisheries in Japan. In 1957 the number of purse seine fleets* were about

* A purse seine is operated, in general, by a group of 5-6 vessels, 2 netting boats, 1 fish finding boats , 2 light boats and 1 fish carrier, this group of vessels is called a "fleet" in this study.

Table 1. Main species caught by round haul nets and other fisheries and the proportion of catches for each type of fisheries in 1956.

Species \ Type of fisheries	Total	One boat purse seine	Two boats purse seine	Lampara net	Other round haul nets	Gill net	Angling	Set net	Beach seine	Trawl net	Lift net	Long line
Sardine	55,014	11,939	12,720	1,222	1,531	18,307	39	2,837	762	0	2,609	
	100%	22	23	2	3	33	0	5	0	0	5	
Round herring	15,986	6,412	4,846	905	400	422	410	625	132	0	1,423	
	100%	40	30	6	3	3	3	4	1	0	9	
Anchovy	92,455	4,191	49,813	3,949	367	79	34	6,630	3,038	19,192	3,846	
	100%	4	54	4	0	0	0	7	3	21	4	
Horse-Mackerel	70,986	15,606	10,536	506	504	1,906	21,087	6,782	641	133	11,555	
	100%	22	15	0	0	0	30	9	1	0	16	
Mackerel	65,711	36,895	7,777	1,392	384	1,556	1,665	7,267	285	615	7,537	
	100%	56	12	2	0	2	2	11	0	1	12	
Skipjack	26,127	227	291	8	37	4	25,036	317	6	0	9	111
	100%	0	1	0	0	0	96	1	0	0	0	0
Tunas	70,436	579	4,041	1	28	6	15,569	1,458	0	0	27	47,852
	100%	1	6	0	0	0	22	2	0	0	0	68

Unit of catch: 1000 Kan (=3.75 metric tons)

2500 and the yearly catches amounted to about eight hundred million metric tons, which corresponds to about 20 per cent of the total catch by the coastal and offshore fisheries. Further, it is noteworthy that more than half the yearly catch of sardines* and horse-mackerel is obtained by the purse seine (Table 1).

The purse seine is mainly used to catch the coastal fish which crowd near the sea surface such as sardine, anchovy, horse-mackerel and mackerel. A certain type of purse seine is utilized for the catch of the pelagic fish such as tuna and skipjack. The scale of the fleets can be classified into the wide range from "no engine" class to "more than 100 tons" class, which is the character of the pelagic fishery fleets such as skipjack and tuna purse seine fleets.

The purse seine was first imported from America to Japan in 1882 and after that time this fishery was favorably developed during the past six decades until World War II by the improvement of fishing gear and method, the mechanization of boats and the extension of fishing-grounds. After World War II, though there were some handicaps such as loss of fishing-ground in Korea, where sardine and mackerel abound, and more importantly, the decline along the coast of Japan of the sardine which is the most important species of fish for this fishery, the purse seine fisher has been carried out actively thanks to the modernization of boats, the utilization of new installations of fishing gears such as the fish finder and the wireless telephone and furthermore the increase in the number of fleets engaged in this fishery.

But this event, namely, the increase in the fishing effort, has brought about a dangerous tendency in the purse seine fisheries themselves, that is, the appearence of some symptoms with reference to the reduction of fish stock by over-catching and the consequent deadlock in the management of these fisheries.

In the present day the purse seine fisheries in our country have been confronted with two important problems, and in this study these problems have been investigated in regard to the fishing power.

Firstly is the problem of the decrease of catches. Fig. 1 shows the change in the yearly catch for the purse seine fisheries during the periods from 1935 to

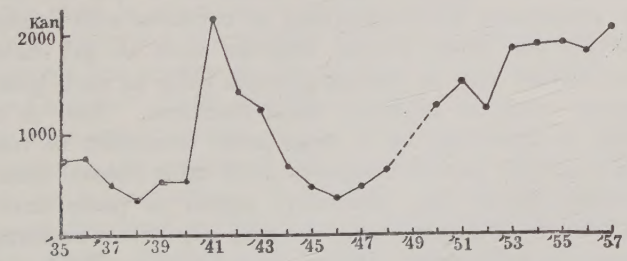


Fig. 1. Yearly catches by round haul nets during 1935 to 1957. (1 Kan=3.75 kg)

1957. From this figure it is clear that the yearly catch began to rise from 1946 and continued to rise largely until 1953, but since then the rise from year to year seems to be very slight.

* "Sardines" as used here refers to sardine (*Sardinia melamosticta*), anchovy (*Engraulis japonica*) and round herring (*Etrumeus micuopus*).

After World War II the fishing effort of the purse seine fleets has resonably risen in both quantity and quality owing to reasons mentioned above. Therefore, the cause of the reasonable rise of the yearly catch during the periods from 1946 to 1953 and the subsequent standstill after 1953 should be investigated carefully from the point of view of fishing resources.

In the study of fishing resources a most important factor is the fishing effort expended. The study of the fishing effort in recent years has been from the point of view of not only its quantity but also its quality. In practice in our country as the quality of the fishing effort of the purse seine fleets has changed greatly from year to year and fleet by fleet, a correct knowledge of the fishing effort must be determined by taking the factor of fishing power* into account.

The reason that the purse seine fisheries have been in a depressed condition in recent years has not been determined yet, but in order to discuss the cause of the decrease of the catch, the fishing power of fleets should first be investigated.

The second problem is the antagonism among the purse seine fleets themselves in various places and between the purse seine fishery and other coast fisheries. Now, the purse seine fleets are too numerous to operate in the limited fishing-grounds and the limited fish stock and besides there is almost no possibility to search for new fishing-ground more off-shore along Japan from the international point of view. Therefore, at present, as the purse seine fleets in one prefecture are compelled to go out fishing to the more favorable fishing-grounds of other prefectures, naturally, antagonism has developed between the fleets in one prefecture and those in other prefectures. Because the fishermen engaged in these fisheries are hoping mutually to establish an effective fishery policy in order to operate an orderly way of fishing, which could be beneficial to all, in the limited fish stock and fishing-grounds by means of consolidation of surplus boats, limitation of construction of large tonnage boats, extension of the common fishing-grounds and limitation of fishing season.

Furthermore, the relation between the purse seine fisheries and other coast fisheries in one prefecture have something in common with antagonism. The purse seine fisheries and other coastal fisheries such as gill nets and beach seines are often carried out in fishing-grounds close to each other and taking the common species such as sardines, horse-mackerel. And in addition, the purse seine fishery is operating on a large scale composed of more than five vessels and with a greater capital compared with other coastal fisheries. Therefore, the purse seine fishery has, naturally, begun to press hard upon other coastal fisheries, and the antagonism has become a problem awaiting solution by fishery regulations in each place. Hence, in order to establish a fishery policy or regulation which would be adequate for the purpose mentioned above, first of

---

* Following Beverton and Holt[1] the fishing effort expended by a particular vessel may be defined as the product of the fishing power of that vessel and the fishing power may be defined by reference to a standard vessel by comparing their catches when fishing at the same time and place. The term "*Fishing Capacity*" is used as a synonym of "*fishing power*" by Margetts[2] (1949) and Parrish[3] (1949).

all, the fundemental data concerning the comparison of the fishing power between the purse seine fleets and other coastal fisheries boats should be determined, especially such as the relation between the fishing power and fishing gear and the comparison of the fishing power between the purse seine fleets and other fisheries boats.

Thus, the studies on fishing power are very useful not only to measure the effect on the improvement of fishing gear and method but also to gain fundamental data to reserve and develop fish stock and to control fishery.

The purpose of this study is to provide practical data concerning the fishing power in order to investigate the problem mentioned above with which the commercial purse seine fishery in Japan is confronted at present.

II. Past History of Studies

The studies of purse seines were started in about 1925 with the diving-research for the observation of the form of the net encircling a shoal and the behaviour of that shoal during fishing operation by Miura[4]. He observed in detail, especially, the characteristic behaviour of fish escaping while encircled in the net.

But there were some restrictions on observation by diving-research, namely, the visual field of the observer was limited to a small part of the net and the diving itself was accompanied with dangerous labours and in addition research in deep-water was very difficult.

Therefore, with a view to facilitate the observation of the net under water, Tauti[5] (1934) established a principle on the relation between experiments on model and full scale fishing nets and based on this principle, many experiments on various kinds of model nets have been performed. Among them the purse seine had been experimented on by Uno[6] (1935), Inoue[4] (1955) and Iidaka[8-13] (1956, 1957). But as the fishing operation of purse seines is very speedy and the deformation of the net is rapid, the observation of the form of net in the water is very difficult even in experimenting with models.

Therefore, there are few studies concerning the physical problems of the purse seine except the studies on the relation between floating power and sinking power by Chigusa[14] (1949) and Miyamoto[15] (1956).

On the other hand, studies of the fishing power have recently been started with the advance in the studies of fish population in order to estimate correctly the effect of the fishing effort. In England the fishing power of trawlers and seiners has been discussed by Beverton[16] (1955), Margetts[2] (1949), Parrish[3] (1949) and Gulland[17] (1956). Parrish and Gulland determined the difference between the catching capacities of trawlers of different dimensions and designs mainly by means of the statistical analysis of variance.

In Japan, Inoue[18-20] (1955-1957) and Iidaka[21-23] (1956-1957) have described mainly the relation between the fishing power and tonnage of seiner or the material of net, and investigated in detail the effect of ordinaly gear being replaced by more powerful ones. In these studies Inoue applied the method of the least square and Iidaka's method was the means of X-test and the statistical

analysis of variance. Yamamoto[24] (1956) has used the figures of distribution of unit catch for the comparison of the fishing power on each fleet.

III. History of Fisheries

The history of the round haul net in Japan entered a new epoch in 1882 with the import of the purse seine from America[25].

The origin of the round haul nets in Japan has not been documented yet, but it has been believed that from ancient times there were some different types of construction of net, one of the most popular net being "Agri-Ami"[26] for sardine in Aichi Prefecture*, which had been carried out from about 1860 and others are like the large scale net "Makase-Ami"[27] which needed some hundred men to operate, a small net operated by six men "Rokunin-Ami"[28] in Chiba Prefecture and "Kanawa-Ami"[29] with rings to close the bottom of net in Ehime Prefecture. Although these nets had been improved partially during previous long periods, an efficient installation such as that on the purse seine had not appeared at last until the purse seine was imported in 1882.

Since 1882 the round haul nets in Japan have been gradually changed to the purse seines and now the purse seines account for over 80 per cent of all the round haul nets.

The purse seine in Japan has been mainly used to catch sardines, horse-mackerel and mackerel, but in recent times skipjack and tuna have been caught too; other species caught are porgy, dorade, flying-fish, suary pike and the young of punctatus.

Among these species sardines are the most important fish from the point of view of the yield. Therefore, it may be seen that the sardine purse seine is representative of the purse seines in Japan.

As horse-mackerel and mackerel purse seines are very similar to the sardine purse seine as regards both the history of the development of the fishery and net construction, they are treated together with sardine purse seines in this description of their history.

Skipjack and tuna purse seins and sardine lampara nets are somewhat different from the sardine purse seine in both the history and the construction of net and so they are explained simply in other clauses.

1) *Sardine purse seine*

"Agri-Ami" in Aichi (Fig. 2) and Chiba Prefectures which was a very useful gear to catch sardines in the age of no purse seines, had been improved upon following the installation of the American purse seine in the lower part of the net to close the bottom with purse rings and a purse line during the period 1885 to 1890.

In 1890 the experimental operations of "Agri-Ami" which had improvemented like the American purse seine had been conducted with success in Chiba Prefecture[28] and for a while it was named as the "Improved Agri-Ami".

In Chiba Prefecture, at that time, beach seines had been the most important

* Prefectures appeared in this study are shown in Fig. 9.

fishing gear for the capture of sardines. But owing to the effect of the success of the operation of "Improved Agri-Ami" the fishermen engaged in the beach seine fishery had begun to replace beach seines with purse seines rapidly. Table 2 shows the state of substitution from year to year in Kuzūkuri-hama which has been a very famous place in Chiba Prefecture for the sardine fishery from ancient times.

In other places, Kochi, Tokushima, Ehime, Yamaguchi, Fukuoka and Kumamoto Prefectures, although some fishermen tried the commercial practice of the American purse seine, it did not always produce good results because the construction of the American purse seine was not suitable to the condition of the sea in Japan and the crew were yet inexperienced in the use of this seine.

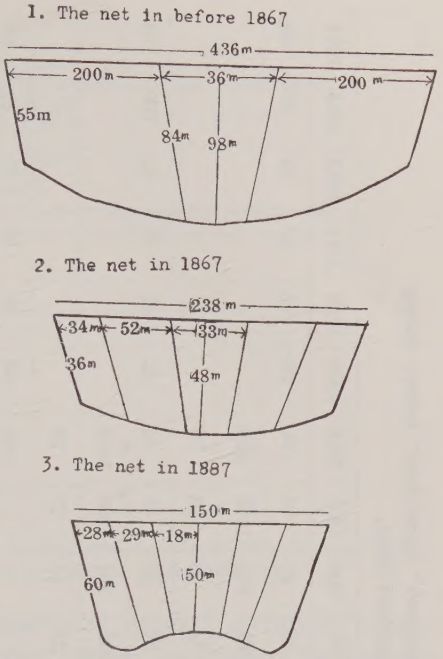


Fig. 2. State of substitution of sardines purse seine in three periods in Aichi Prefecture.

Therefore, during the period 1893 to 1897 the Fisheries Investigation Station engaged[30] in training and diffusing the purse seine at various places with the American purse seine which was somewhat improved in order to be suitable to the fishing-grounds and fishing boats of Japan. By the results of this successful operation fishermen in various places recognized that the purse seine was an excellent net and introduced it gradually into the commercial fisheries.

The purse seines used in America in about 1882 were distinguished into two types, large and small size nets; the large size net ranged from 255 to 290 metres, from 15 to 35 metres in length and depth respectively and the seiner used in single is carried to the fishing-ground on board the mother ship which is a steamer or sailing-ship (60–80 tons).

The purse seine constructed by the Fisheries Investigation Station[31] was 275 metres in length and 30 metres in depth as shown in Fig. 3 and it was operated by a pair of engineless seiners with working sculls.

Taking over from the training by the Fisheries Investigation Station, the Fisheries Experiment Stations in various prefectures tried[8] frequently to teach the technique of the purse seines during the three decades following 1898 and thus the purse seines were widely put in use as commercial fishing gear instead of beach seines and lift nets.

During the past decades the most remarkable event was the machnized fishing[28], namely, in 1910 the utilization of an engine boat for a dug boat of seiner was experienced by the Fuji-Maru of Shizuoka Prefecture Fisheries Experiment Station and during the period 1918 to 1923 the use of an engine boat as

Table 2. Comparison between beach seine fishery and "Aguri-Ami" fishery during 1882 to 1914 in Kuzyūkuri-hama.

	Year	1882	1887	1890	1902	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
Large size beach seine	Number of seines	174	266	194	141	95	93	85	84	87	74	74	63	55	59	56
	Total catch (1,000 Kans)						2091	665	1153	839						
	Catch per seines (Kan)						22	8	14	10						
Agri-Ami (purse seine)	Number of seines				225	50	60	49	47	44	42	43	56	62	100	110
	Total catch (1,000 Kans)						1640	761	1289	1468						
	Catch per seine (Kan)						27	16	27	33						
Small size beach seine	Number of seines				19					21	43	40	55	75	81	95
	Total Catch (1,000 Kans)									247						
	Catch per seine (Kan)									12						

Note: 1 Kan=3.75 Kg

Table 3. Composition of the purse seine fleets in 1935.[3]

Two boats purse seine					One boat purse seine				
Length of net	Tonnage of seiners	Tonnage of transport	Number of Auxiliary boat	Number of crew	Length of net	Tonnage of seiner	Tonnage of transport	Number of Auxiliary boat	Number of crew
m 300~400	tons 15~40 (40~100HP)	tons 10~35	3~5	70~80	m 450	tons 20~50 (100 HP)	tons 10~40	2~4	35~45

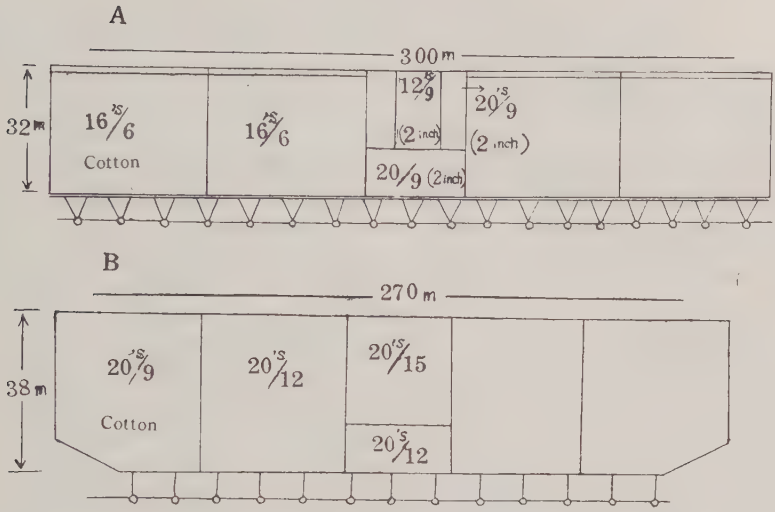


Fig. 3. Specification of a typical purse seine in America in about 1890 (A) and the purse seine constructed by Fisheries Investigation Station in Japan 1893 (B).

a seiner by itself was practiced by the Senkaku-Maru (39 tons, 50 Hp) of Yamaguchi Prefecture Experiment Station, This event marked an epoch in the history of the purse seine fishery as the beginning of the age of engine boats and thus fishing-grounds were extended more off-shore compared with the age of no engine boats.

On the other hand, the experiences of fish luring lamps had been made together with the test of the purse seine during the period 1920 to 1930 by Nagasaki and Shizuoka Prefecture Fisheries Experiment Stations. From about 1897 oil lamps had been used instead of wood, next, carbide lamps which were well used changing into oil lamps in about 1906 and electric lamps are now being used throughout the whole purse seine fleets. Following the introduction of the purse seine fishery in various places the yield was gradually increased; it was especially remarkable at Chiba, Ehime, Nagasaki Prefectures and North Korea.

According to the report[33] of the purse seine fishery in 1937 by the Fisheries Bureau, Ministry of Agriculture and Forestry, the tonnage of purse seiners on the whole at that time was less than 20 tons and one boat purse seiners were about four times as many in number as the two boats purse seiners, but the catch per one boat of the former was one half as much as the latter.

The organization of the purse seine fleets at that time is shown in Table 3.

One or two examples of the interesting fishing methods adopted at that time are mentioned below: When a large shoal is found, some seiners gather circularly around the shoal and shoot the nets in cooperation with them so as to cut off the way of escape of fish and after the hauling of nets the fish caught is divided into the operated fleets. Although this method was very useful, now it is not in use because such a large shoal as to necessary for the beneficial use of this method is seldom discovered. In mackerel purse seines, in Wakasa Bay, a driving net as illustrated in Fig. 4 was used to prevent escaping fish from

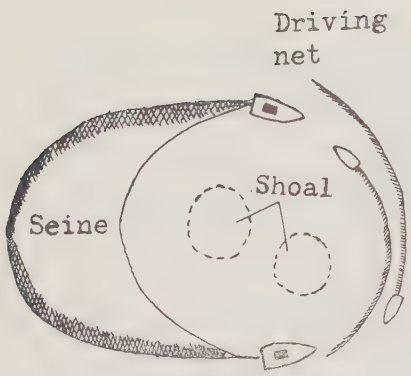


Fig. 4. Mackerel purse seine with encircling nets.

encircling the net. But this has been put out of use, too, since the advent of the more efficient winching system.

The catch of sardine from about 1910 had increased rapidly and at last in 1936 it reached the maximum level but ever since it has gradually decreased.

The cause of this fact is not obvious yet, but it may be assumed that this is due to any one of the following three factors; the first is the decrease of the population of sardine themselves, the second is the variation of the sea condition in which sardine are living and spawning, and the third is the removal of sardine to more off-shore regions where the fishery has not yet been operating.

Table 4[34] shows the catch of sardine by three kinds of net; purse seines, set nets and gill nets in North Korea which was known as a very famous fishing-ground at that time.

According to this Table the total catch by three kinds of fisheries reached the maximum in 1939 and since then they have dropped. Aikawa (1943) who is the author of this Table, pointed out that from this Table the stock of sardine began to decrease after about 1935. The values in the right column in the three kinds of fisheries in the Table indicate the ratio of the catch for each year during 1934 to 1942 to that in 1933. The ratio of the purse seines increased until 1939 but that of the set nets and the gill nets already decreased several years prior to 1939, namely, the set nets from 1935 and the gill nets from 1936. These results may be summarized as follows. In spite of the decreasing of the stock of sardine from about 1935 only the purse seines held the increase of the catch for a while after 1935, and this fact may be owing to the activity of the purse seines compared with the passivity of others, such as the gill nets and the set nets.

After World War II the purse seine fishery has greatly been developed by the use of fish finders, wireless telephones and the change from cotton fiber nets to synthetic fiber nets. Especially, the use of fish finders from about 1948 has brought a revolutionary effect not only in the fishing power of the purse seine fleets but also in the cultivation of new fishing-grounds. Wireless telephones which had been used only in trawl fisheries before World War II has begun to fit into the purse seine fleets since 1947. This installation is very useful to keep in contact with other fleets and the base office.

The first test of synthetic fiber nets was made with Amiran (Nylon) fiber net in Nagasaki Prefecture in 1950[35]. Though the fiber has some faults as a purse seine, for example, the density of the net is light so that the form of net in the water is easy to vary and more sewing of nets is troublesome compared with cotton fiber for knots loosen easily, the practical test was successful and after that time fishermen at various places have used Amiran fiber nets and other synthetic fiber nets such as Cremona (Vynlon) and Saran. At present

Table 4. Comparison of the catch by purse seine, set net and gill net on Kankyō Hokudō in North Korea during 1933 to 1942. (By Aikawa)

Year	Purse seine				Set net				Gill net				Sum total catch (ton)
	Total catch (ton)	Number of net	Catch per net (ton)	Ratio of the catch*	Total catch (ton)	Number of net	Catch per net (ton)	Ratio of the catch*	Total catch (ton)	Number of net	Catch per net (ton)	Ratio of the catch*	
1933	60,928	34	1,792	1.00	21,415	24	892	1.00	64,492	1,698	48	1.00	147,335
1934	119,845	43	2,788	1.55	69,706	38	1,834	2.06	110,008	1,810	61	1.27	299,559
1935	217,516	56	3,884	2.16	34,781	44	790	0.89	122,641	2,202	56	1.17	374,938
1936	296,284	72	4,112	2.29	34,620	94	368	0.41	84,712	2,827	30	0.62	415,616
1937	478,068	98	4,878	2.70	71,487	83	861	0.97	110,949	2,930	38	0.79	660,504
1938	367,863	119	3,091	1.73	33,413	94	355	0.40	53,065	2,067	26	0.54	454,341
1939	639,769	119	5,376	3.00	39,464	83	475	0.53	97,172	1,867	52	1.08	766,405
1940	451,758	132	3,422	1.90	17,030	77	221	0.25	54,757	1,745	31	0.65	523,545
1941	256,420	123	2,085	1.16	18,554	46	403	0.45	25,198	1,725	15	0.31	300,172
1942	938	133	8	—	679	56	12	—	528	—	—	—	2,141

Note: *: Ratio of the catch per net in each year to that in 1933.

Table 5. Change of the equipment of boats and dimension of nets of Nagasaki Prefecture purse seine fleets.

Year	Mean tonnage of seiner (ton)	Horse power of seiner (HP)	Composition of fleet	Fish luring lamp (Candle power)	Fish finder	Dimension of net (m)	Catch per fleet in a year (Kan)
1935	16.3	46.3	Seiner 1 Light boat 2	800~1000	0	D 60~ 90 L 370~450	186,900
1940	17.1	48.3	Same the above	800~1000	0	D 60~ 90 L 450~750	unknown
1945	19.4	60.0	Same the above	1000~2000	1 fleet	D 60~ 90 L 450~750	121,800
1950	32.1	100.5	Seiner 1 Light boat 2	2000~3000	80 fleets (One-third of the whole)	D 90~ 120 L 900~1400	298,500
1953	50.1	108.7	Seiner 2 Light boat 2 Transport 2	2000~3000	The whole fleet	D 160~ 190 L 1300~1800	319,000
1955	53.6	181.5	Seiner 2 Light boat 2 Transport 2	3000	The whole fleet	D 160~ 190 L 1300~1800	298,500

Note: D: Depth L: Length

(1958), 60 per cent of the purse seines have been changed from cotton fiber nets to synthetic fiber nets[36].

The general tendency of the change of the composition of the purse seine fleets and net in Nagasaki Prefecture during 1935 to 1955 is shown in Table 5.

On the other hand, viewed from the point of fishery resources, the catch of sardine has decreased from year to year after 1945 (though once there was a tendency to recover sardine stock during the period 1950 to 1953) in the East China Sea which is a main spawning-ground and the most favourable fishing-ground near Japan. Such a tendency is the same on anchovy resources in the North and Middle Pacific Regional Sea*. Anchovy purse seine fishermen in these regions are hardly maintaining catches by means of over-operation with the increase of the number of days at sea and the number of pursing in a day. As a counterplan to the poor fishing, some of them have changed to the skipjack and tuna purse seine fishery which have become favourable after World War II in the North Pacific Regional Sea.

As regards the sardine purse seine fishery, fortunately, as the stock of horse-mackerel and mackerel in the East China Sea have been still holding abundantly and they are especially found in abundance in the vicinity of Tushima and Saishutō, sardine purse seine fishermen in Nagasaki Prefecture have been fishing off Tushima and Saishutō with the nets constructed so as to suitable to catch horse-mackerel and mackerel.

With the extension of the fishing-grounds the purse seine boats have been modified to a large size, from 50 tons class to 70–80 tons class and the dimension of nets has been extended, too, as shown in Table 5.

However, owing to the Rhee Line which was set by Korea in 1952 in the position as shown in Fig. 9, the fleets based in the various places on the East China Sea Region have found it is impossible to fish off Saishutō and it's neighbourhoods. Therefore, they have been compelled to go fishing off other prefectures, for example, the fleets in Nagasaki Prefecture enter off Yamaguchi, Shimane, Tottori, Saga, Fukuoka and Kumamoto and such a fishing operation has become the origin of antagonism in each prefecture.

In order to break this deadlock in the fishery in the East China Sea a special large size purse seiner, the Genpuku-Maru (230 tons) was constructed in 1956 for the pelagic fishing and the next year her first practical operatical operation was tested in the east area of the East China Sea which has been known as a fishing-ground of mackerel pole and line fleets. But this result was not so desirable for the purse seine fishery itself.

2) *Skipjack and tuna purse seine*

In skipjack and tuna round haul nets before 1882, when the American purse seine was imported, the following three were typical nets; skipjack "Agri-Ami" in Aichi Prefecture, skipjack "Ō-Ami" in Kochi Prefecture and tuna "Maki-Ami" in Miyagi Prefecture.

These nets had some interesting features respectively in the construction of nets and fishing methods. But since 1882 skipjack Ō-Ami has gone out of

* Division of the sea along coast of Japan is shown in Fig. 9.

use and skipjack Agri-Ami and tuna Maki-Ami have been improved upon and developed as the purse seine.

1) Skipjack Agri-Ami[28]

Fig. 5 shows a plan showing method of working the skipjack Agri-Ami. The size of net is approximately 800 metres in length and 80 metres in depth and the net is mostly made of straw fiber except the bag net which is made of hemp fiber and the size of mesh range from 12 to 30 centimetres (streched mesh size). This net is operated with two boats, one is a seiner with about 30 men crew and the other is an auxiliary boat with few fishermen.

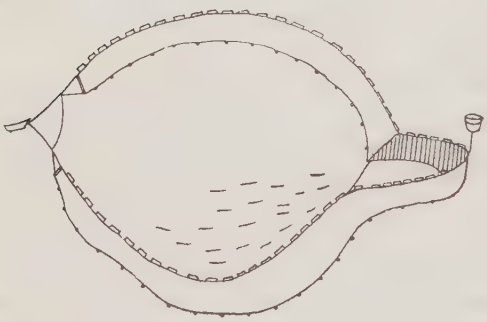


Fig. 5. Plan showing method of working skipjack "Agri-Ami".

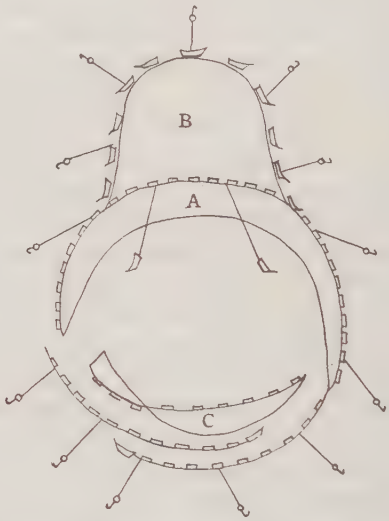


Fig. 6. Plan showing method of working skipjack "Ō-Ami".

2. Skipjack Ō-Ami[26]

This net is divided into three parts as shown in Fig. 6, (A) Encircling net, (B) Bag net and (C) Driving net. The encircling net is approximately 500 metres in length and 60 metres in depth and the size of the mesh is very large. The bag net is made of hemp fiber and is 30 metres in circumference and lacks floats, but instead of them the net is hold on the sea-surface by small boats with one or two fishermen. The driving net constructed in the same way as the encircling net. Skipjack Ō-Ami is operated with ten boats and some hundred crew and as soon as a shoal is surround with the encircling net the shoal is drived away into the bag net with he encircling net and finally escaped with a plan net.

3. Tuna Maki-Ami[37]

Originally this net was a kind of surrounding gill net. But as it was hard to catch tuna with gill net because tuna has the behaviour of being frightened by the existence of gill net, it was modified to the round haul net with bag net instead of gill net. However, as once the fish come into the bag net it is easy to escape back the same way, a plan net which is attached to the front of

the bag net is lifted with ropes in order to intercept the retreat of fish (Fig. 7). The bag net is 37 metres in length, 27 metres in depth and the wing net is 375 metres in length and 15 metres in depth. This net is operated by 26 fishermen with 3 boats.

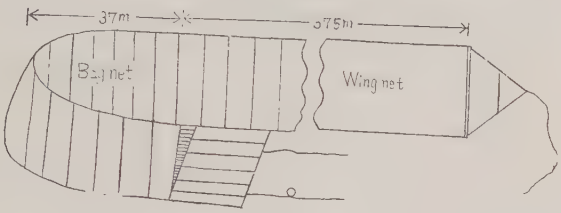


Fig. 7. Plan showing method of working tuna "Maki-Ami".

The skipjack and tuna purse seine fishery was started in 1913 in Miyagi Prefecture with the No. 2 Yosimine (30 tons, 20 Hp), next, Tokyo High Sea Fisheries Company engaged in this fishery in 1915 with the Kitushō-Maru, steam trawler, and these new practical operations laid the fundation of the commercial skipjack and tuna purse seine fishery in use nowadays.

Kanagawa Prefecture Fisheries Experiment Station[33] made the experimental operation of the one boat purse seine and the two boats purse seine during 1893 to 1928 in Sagami Bay and tried to improve on the tuna Agri-Ami which had been operated heretofore in this area.

In other areas, Chiba, Ehime, Ōita Prefectures and Hokkaido, Fisheries Experiments Stations conducted trials with skipjack and tuna purse seine to fishermen but no successful results were obtained. Therefore, the skipjack and tuna purse seine fishery flourished only in Kanagawa, Shizuoka and Miyagi Prefectures until about 1930. But, unfortunately, as skipjack and tuna shoals showed a tendency to remove far off-shore in these regions at about the same time the purse seine fishery, which had been nothing but one of the coastal fisheries at that time, declined naturally and instead of purse seine boats skipjack hooking boats and tuna long-line boats were increased in number and size in order to fish far off-shore. Until the end of World War II this fishery had been hardly maintained by a few fleets on the coast of the North Pacific Region.

After World War II the American purse seine for tuna, which was imported from America in 1948, was experimented on by Tokyo Fisheries Company with the Shirauri-Maru (98 tons, 250 Hp) in 1948 in the North Pacific Regional Sea and receiving impetus from the success of this operation, skipjack and tuna purse seine fishery have been in operation again in this region.

In addition, at about the same time the sardine purse seine fishery had begun to decline in the North Pacific Regional Sea and some of the fishermen changed to the skipjack and tuna purse seine fishery with new boats constructed specially for this fishery.

Nowadays this type of fishery is changing to the two boats purse seine from the one boat purse seine. Table 6 shows the tendency transposed from one side to the other in Miyagi Prefecture which is the most important fishing area in the North Pacific Region.

Table 6. Tendency transposed from one boat purse seine to two boats purse seine during 1952 to 1958 in Miyagi Prefecture. (Skipjack and tuna purse seines).

Year	One boat purse seine		Two boats purse seine	
	Number of fleet	Mean tonnage of seiner (ton)	Number of fleet	Mean tonnage of seiner (ton)
1952	29	51.44	15	31.65
1953	19	54.00	13	40.94
1954	11	52.44	12	53.83
1955	4	55.65	12	61.03
1956			17	70.65
1957			22	77.58
1958			24	80.96

3. *Sardine lampara net*

Lampara net fisheries have been carried out to take mainly sardine and anchovy in the East China Sea, especially, in Nagasaki and Kumamoto Prefectures.

It is said that the establishment of the lampara net was not so long ago and it had already been modified from the lift net (Hachida-Ami) to the present type in the middle of the 19th century.

Fig. 8 shows a comparison of the construction between the two boat lift net (Hachida-Ami) and the lampara net. The lampara net consisted of two parts: the bag net and a pair of wing nets, and manila ropes of 225 metres length is used as the hauling rope of one half of the net.

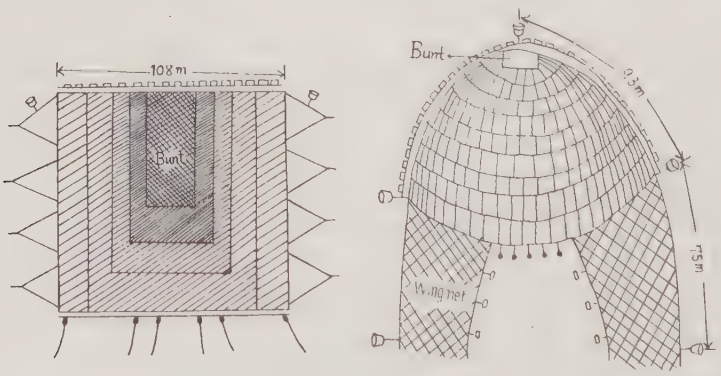


Fig. 8. Comparison of the construction between lift net and lampara net.

At the present time sardine lampara net fleets are carried on in the common fishing-ground with two boats purse sein fleets of less than 20 tons class in the East China Sea.

The comparison of the catch between the lampara net fleets and the two boats purse seine fleets, both of which are operating on the coast of the East China Sea, is shown Table 7[39] dividing into four classes; "engineless class", „0–5 tons class", "5–10 tons class" and "10–20 tons class",. According to this

Table 7. Comparison of the number of cruise and the catch between purse seine fleets and lampara net feets. (1957).

Year	Kind of net	Engineless				O-5 tons class				5-10 tons class				10-20 tons class			
		N	n	C *	c (Kan)	N	n	C *	c (Kan)	N	n	C *	c (Kan)	N	n	C *	c (Kan)
1954	Lampara net	222	77	31.8	0.41	17	53	10.4	0.19	6	59	40.3	0.68	8	104	36.7	0.35
	Purse seine	199	76	59.5	0.78	2	92	25.0	0.27	8	138	57.0	0.41	13	117	85.0	0.73
1955	Lampara net	160	78	28.5	0.37	70	86	17.4	0.20	9	52	21.7	0.42	3	139	45.4	0.32
	Purse seine	177	83	56.0	0.67	8	76	23.7	0.31	23	93	43.7	0.47	16	125	79.5	0.63
1957	Lampara net	124	67	40.6	0.60	40	77	28.8	0.39	8	73	32.5	0.44	4	31	49.0	0.35
	Purse seine	170	69	44.4	0.45	27	125	37.6	0.32	23	110	38.5	0.38	26	89	58.5	0.65

Note: N: Total number of fleet C: Yearly catch per fleet * (1000 Kans)
n: Mean number of cruise year c: Catch per fleet and cruise

Fig. 9. Various prefectures which appeared in name in this study and conventional divisions in the sea area of our country.

table it seems that only the 10 20 tons class of two boats purse seines is about twice as much as the lampara net on the catch per one fleet and cruise, but in the other classes there are no definite differences between the two.

IV. Fishing Gear and Fishing Method

1) *Fishing gear*

The construction of the purse seine may be summarily described as below.

Generally purse seines for the capture of large and speedy fish such as skipjack and tuna are larger in both the depth and the length than those for small fish such as sardine and anchovy. Purse seines for skipjack and tuna are

1,000–1,500 metres in length and 45–90 metres in depth. Other seines for horse-mackerel and mackerel are 500–900 metres in length and 150–220 metres in depth.

Nagamine (1940)[40] reported that as a general rule the ratio of net-depth to net-length was the range from 8 to 17 per cent. But in recent years this ratio had changed remarkable according to the increase of net-depth after using fish finder in about 1953. At present, the ratio of net-depth to net-length of the purse seine for sardines ranges from 14 to 20 per cent and for horse-mackerel and mackerel are from 30 to 50 per cent.

Fig. 10 shows the construction of three typical nets. A is an American type and B, C are of the Japanese type, and, B mainly shows the type of one boat purse seine and C shows the type of two boats purse seine.

The meshes of the purse seine is decided according as the size of fish which it is intended to catch. Table 8 shows the smallest mesh in each part of net (it is usually a part of bunt) for each type of the purse seine.

The specification of a few examples of each type of the ordinary purse seines are given in Figs. 11, 12 and 13.

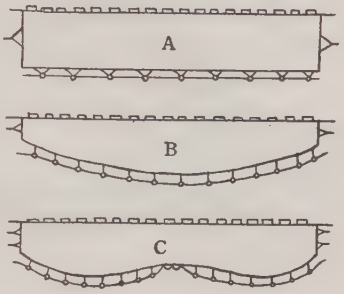


Fig. 10. Diagrams of three typical nets.
A: American purse seine type
B, C: Japanese purse seine type

Table 8. Mesh size on the bunt of purse seine for various species of fish.

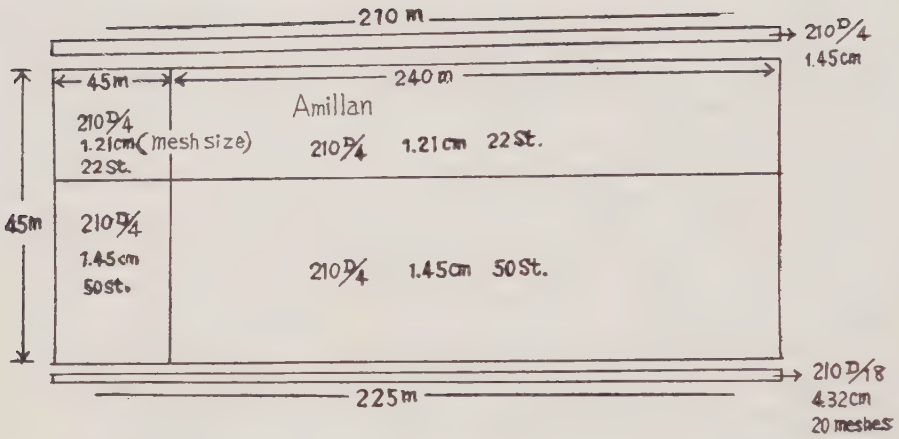
Kind of purse seine	Mesh size on the bunt (cm)
Anchovy purse seine	1.16~1.50
Small-size sardine purse seine	1.37~1.50
Large-size sardine purse seine	2.53~3.00
Mackerel and horse-mackerel purse seine	3.76~4.30
Skipjack and tuna purse seine	6.00~9.00

2) *Fishing method*

The fishing method is more or less different by operation time (day time and night time), fishing-ground and species of fish. Of course it is also changed by the type of the net used such as the one boat purse seine and the two boats purse seine. The substance of the fishing method is composed of three factors; the first is the searching of fish, the second is the luring of fish and the last is the operation of net.

1. Searching of fish.

Before using the fish finder, a shoal of fish is located by the signs that appear on the sea-surface, changing of the colour by crowding fish, the individuals of jumping fish, the rippling by swimming fish, the bubbles by breathing fish on the sea-surface and the flying birds above the sea-surface. However, at



I. Rope

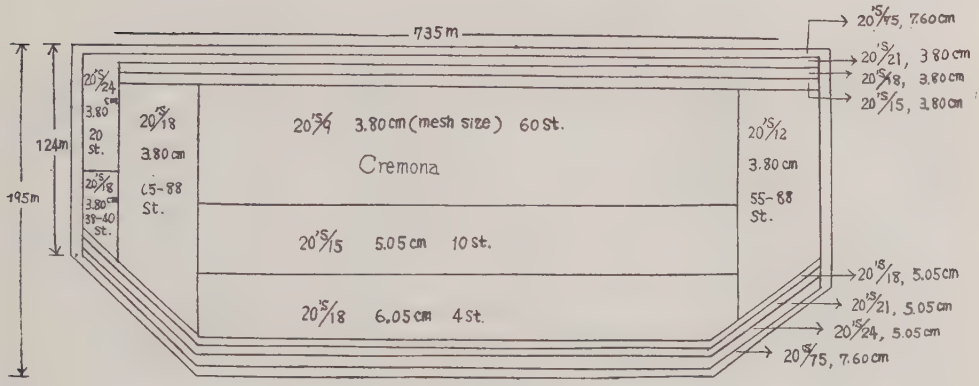
Name of rope	Material	Number of ropes	Twine size in dia. (mm)	Length (m)
Cork line	Manila rope	3	7, 10, 15	220
Lead line	〃	3	7, 10, 15	230
Bridle	〃	38	13	1.5
Purse wire	Wire rope	1	13	300

II. Float and Sinker

Name	Material	Size	Number	Intervals
Float	Synthtic float	30.3 cm×15 cm ×7.6 cm	342	9 per 7.5 m
Sinker	Lead	375 g	418	11 per 7.5 m
Purse ring	Iron	Ring dia. 12 cm	38	3 per 4.5 m

Fig. 11. Strip plan of anchory purse seine (one half of net) and it's appurtenances at Chōsi in Chiba Prefecture (Seiners are 25 tons).

Note: One strip is 100 meshes in depth.



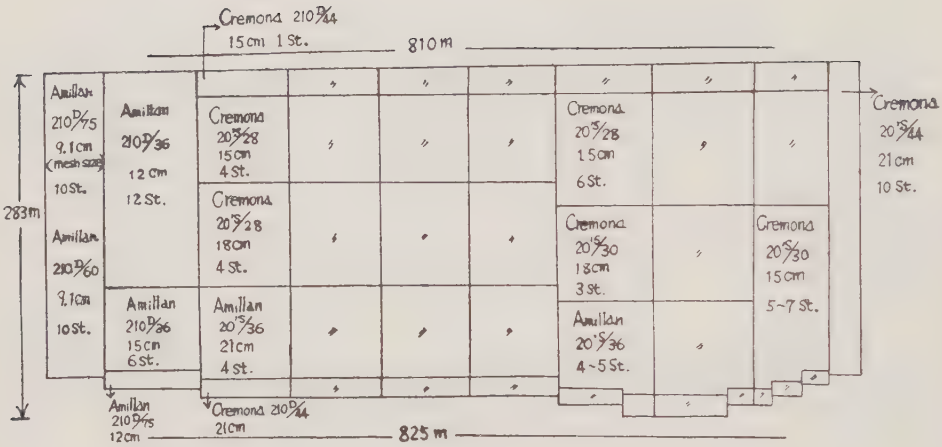
I. Rope

Name of rope	Material	Number of ropes	Twine size in dia. (mm)	Length (m)
Cork line	Manila rope	2	16, 18	735
Lead line	〃	2	〃	810
Bridle	〃	180	9	1.5
Purse wire	Wire rope	1	18	960

II. Float and Sinker

Name	Material	Size	Number	Intervals
Float	Synthtic float	Dia. 15 cm Length 21 cm	1960	4 per 1.5 m
Sinker	Lead	375 g	4500	8-10 per 1.5 m
Purse ring	Iron	Ring dia. 12 cm	180	1 per 4.5 m

Fig. 12. Strip plan of horse-mackerel and mackerel (and Sardine) purse seine and it's appurtenances in Nagasaki Prefecture. (Seiner is 79 tons)



I. Rope

Name of rope	Material	Number	Twine size in dia. (mm)	Length (m)
Cork line	Manila rope	2	16, 18	810
Lead line	〃	1	16, 18	825
Bridle	〃	110	18	3
Purse wire	Wire rope	1	18	900

II. Float and sinker

Name	Material	Size	Number	Interval
Float	Synthtic float	Dia. 12 cm Length 18 cm	1500	6 per 1.5 m
Sinker	Lead	375 g	5050	10 per 1.5 m
Purse ring	Iron	Ring dia. 15 cm	110	1 per 7.5 m

Fig. 13. Strip plan of Skipjack and tuna purse seine (one half of net) and it's appurtenances at Ishinomaki in Miyagi Prefecture. (Seiners are 84 tons)

present the searching of fish is very easy by using the fish finder.

In skipjack and tuna purse seine fleets, the fish finder is not used even now but they can still detect mostly by signs of the sea-surface as mentioned above and occasionally an aerial reconnaissance has been adopted.

2. Luring of fish.

To make a mass of fish, generally, the fish luring lamp is used, especially, against fish which have a tendency towards light such as sardine, horse-mackerel and mackerel. Generally, two light boats are used in one purse seine fleet.

The case of capturing sardines in the East China Sea two lights boats leave at long interval, it is as about 1,000 metres from each other, but for horse-mackerel and mackerel the interval of one from the other is shorter, usually 500–700 metres because their character is one of lesser attraction towards lights as compared with sardines.

Nevertheless, it is hard to attract horse-mackerel and mackerel near the sea-surface. Power of light ranges from 2,000 to 8,000 candle-power for capturing sardines, horse-mackerel and mackerel.

In the fishing-ground, at first two light boats keep apart at a certain interval and attract the fish. Soon they begin to close transitively towards each other with attracting fish by the tide and the wind.

When the boats come close to each other, the one puts out the light in order to lure the fish, which are attracted in groups round its side, towards the round of the other light boat and then at once leaves silently from the other so as to not let the fish out and lights its lamps again on a far away point from the other to start the next operation.

3. Operation of net.

Two boats purse seine: When the fleet arrives at the fishing-ground two seiners are fastened to each other at the bows and half of the nets which are loaded on both seiners are sewn together with the salvages of the bunts. As soon as a shoal is discovered the mooring of the two seiners at the bows is cast off and the net is thrown into the water at once from the sides of boats.

At first the bunt of the net is thrown and the other parts are thrown in succession naturally with the seiners set in motion. The direction of the lay out net should be decided by swimming speed and course of fish and direction of the wind and the tide.

Then the seiners steam round in a half circle to each other and when they come together, the attached ropes are handed over to each other and the purse line is placed on the winch drum on the seiners and the closing of the bottom of the net begins. The bottom of the nets is gathered up toward the side of the seiners and when the foot line is drawn on the deck, the purse line is drawn out through the rings, thus the hauling of the nets begins.

The float line is piled on the stern and foot line is on the bow. For the small purse seine such as anchovy purse seine the net is manipulated by man power but the large purse seine as horse-mackerel and mackerel purse seine is hauled by the net-hauler.

To prevent the escape of the fish from the bottom of the net, the weight

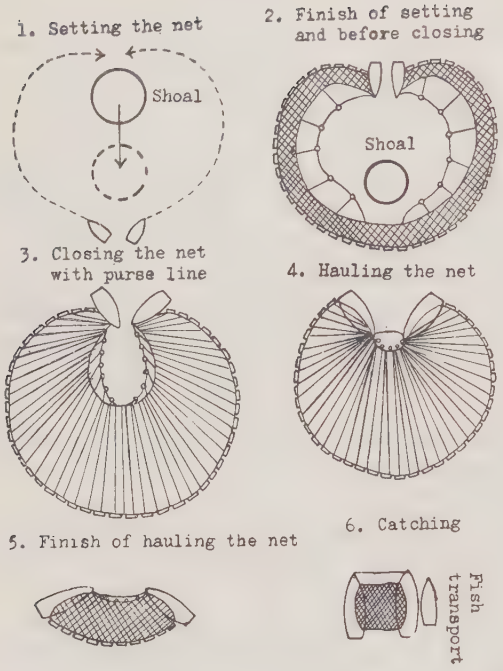


Fig. 14. Diagrammatic illustration of the operation by two boats purse seine fleet.

plump is occasionally used to shut the opening at the lower part of the net. The plump has been used mainly for horse-mackerel and mackerel purse seine in the East China Sea, it's weight being about 900 kg for one boat seine and about 650 kg for two boats seine but in the case of the latter two plumps are used. Diagrammatic illustration of the operation by two seine boats shown in Fig. 14.

One boat purse seine: The fishing method is very similar to two boats purse seine.

The material difference between the two is the action of the auxiliary boat, namely for one boat purse seine it stays behind at the starting point of the lay out net and holds the end of the purse line, spring rope and wing net until the setting of the net is finished and as soon as the seiner returns again at starting point the auxiliary boat hands over their ends to the seiner. But for two boats purse seine the auxiliary boat is only used to adjust the form of encircled net.

In Japan, horse-mackerel, mackerel and sardine are taken by one boat purse seine, while anchovy, tuna and skipjack are taken by two boats purse seine.

V. The Method of Measurement of the Fishing Power

In the case of the comparison of fishing power with two fleets or over which are operating in the same fishing-ground, the use of the catch per unit time is the easiest method. But the catch per unit time should be only used when these fleets are fishing in the same place and time, because the catch is greatly influenced by the density of the shoal and the condition of the weather and the sea.

Of course, when the fishing-ground and time are not the same for each fleet the catch per unit time is impossible to use. In the present study the catch per unit time was used as a method of the measurement of the fishing power, but when there is a necessity for measuring the fishing power more precisely and the use of the catch per unit time was impossible by the reason mentioned above the following Tauti's methods were applied.

1. The method of measurement of the fishing power when the fleets are fishing in the same place and time.
2. The method of measurement of the fishing power when the fleets are fishing in the different place and time.
3. The method of estimation of the fishing-rate from the variation of monthly catch in a year.
4. The method of estimation of the fishing-rate from the variation of the catch per unit time.

The details of the methods are as follows.

1) *The method of measurement of the fishing power when the fleets are fishing in the same place and time.*

In this method, at first, it must be assumed that each fleet, which is the subject of investigation, is always fishing in the same fishing-ground and is similarly situated with regard to the condition of fish stock, the weather and sea and the market price.

The catch in the day i by standard fleet is indicated by Xi and relative fishing power among the fleets $A, B, C, \ldots$.respectively, are indicated, by $a, b, c, \ldots$.respectively, which are calculated from their catch. The difference of the fishing power among each fleet may be due to the difference of the capacity of boats, engine, the net construction and the skill of crew.

The difference among the actual catch $Ai, Bi, \ldots$.respectively, in the day i and the imaginary catch $aXi, bXi, \ldots$.respectively, in the same day, namely, $Ai-aXi$, $Bi-bXi, \ldots$.respectively, may depend upon the difference on the conditions of boats, engines, nets, crew and other conditioning elements among the fleets $A, B, \ldots$.respectively, in the day i. Therefore, $Xi\,(i=1, 2, \ldots.)$ and $a, b, \ldots$.respectively, may be decided with the aid of the method of the least square so as to be satisfy the following equations:—

$$\frac{\partial}{\partial x}\sum_i[(Ai-aXi)^2+(Bi-bXi)^2+\ldots.]=0 \qquad \ldots\ldots\ldots(1)$$

$$\frac{\partial}{\partial a}\sum_i[(Ai-aXi)^2+(B_1-bXi)^2+\ldots.]=0 \qquad \ldots\ldots\ldots(2)$$

$$\frac{\partial}{\partial b}\sum_i[(Ai-aXi)^2+(Bi-bXi)^2+\ldots.]=0 \qquad \ldots\ldots\ldots(3)$$

which may be rewritten as

$$aAi+bBi+\ldots.=(a^2+b^2+\ldots.)\,Xi \qquad \ldots\ldots\ldots(1)'$$

[$i=1, 2, \ldots$.respectively, neglect fleets which did not operated on the day i]

$$\sum_i AiXi=a\sum_i Xi^2 \qquad \ldots\ldots\ldots(2)'$$

$$\sum_i BiXi=b\sum_i Xi^2 \qquad \ldots\ldots\ldots(3)'$$

[neglect days when the fleets $A, B, \ldots$.respectively, did not operated]

Table 9. One example of the calculation of the relative fishing power when the fleets are operating in the same place and time. (on the fleets at Tateyama in Chiba Prefecture, see, VI. §1, Table 18)

Fleet	A			B			C			D			E		
Material of net	Cremona, Amillan			Kanebian			Cremona			Cremona, Amillan			Cotton		
Date	A_i	A_iX_i	A_ia	B_i	B_iX_i	B_ib	C_i	C_iX_i	Cic	D_i	D_iX_i	D_id	E_i	E_iX_i	E_ie
	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan
June 2	500	2.3	480	400	1.9	380	800	3.7	1290	410	1.9	575	470	2.2	385
3	2000	25.0	1920	1500	18.6	1420	1750	21.8	2830	1000	12.4	1400	880	10.9	720
4	200	1.2	192	200	1.2	190	300	1.7	486	1200	6.9	1680	1100	6.3	900
5	200	1.4	192	800	5.6	760	2100	14.7	3400	100	0.7	140	300	2.1	246
6	250	1.8	240	2500	18.0	2370	600	4.3	970	700	5.2	980	100	0.5	82
7	150	0.2	144	200	0.4	190	400	0.8	650	150	0.3	210	440	0.9	360
8	60	0.2	58	800	3.0	760	60	0.2	97	60	0.2	84	40	0.1	32
9	300	3.3	288	400	3.3	380	1500	12.4	2430	300	2.5	420	2400	19.8	1970
10	2000	34.2	1920	2800	48.0	2660	3100	53.0	5020	2800	48.0	3920	700	12.0	574
11	1400	16.3	1345	200	2.3	190	1600	18.5	2590	1200	14.0	1680	520	6.0	426
12	100	0.9	96	1300	11.4	1235	500	4.4	810	1000	8.8	1400	1870	16.5	1530
13	2400	30.1	2310				1500	18.8	2420	3300	41.4	4620	950	11.9	780
15	2000	19.5	1920	1200	11.7	1140	600	5.8	970	1400	13.6	1960	800	7.8	655
16	1000	17.3	960	1000	17.3	950	3100	53.0	5030	2600	45.0	3640	1300	22.6	1060
17	600	5.5	575	1400	12.9	1330	1200	11.1	1940	900	8.3	1260	1400	12.9	1150
19	300	3.6	288	200	2.5	190	2200	23.0	3560	1500	15.8	2100			
22	200	1.3	192	100	0.6	95	1000	6.2	1620	1180	1.3	1650	200	1.3	164
23	350	1.7	336	80	0.4	76	400	1.9	648	400	1.9	560	610	2.9	500
26	200	0.9	192	400	1.9	380	300	1.4	486	800	3.6	1120	900	4.2	740
28	900	6.9	865	50	0.3	47	900	6.9	1460	1400	10.8	1960	600	4.6	493
30	1000	11.5	960	700	8.0	665	4400	50.5	7120	2000	23.0	2800	400	4.6	328
Total	16110	185.2		16230	169.3		28130	314.3		24400	271.6		15980	150.1	
Relative value	185.2/192.8=0.96			169.3/177.0=0.95			314.3/192.8=1.62			271.6/192.8=1.40			150.1/181.8=0.82		

Table 9. (Continued)

Fleet	F			G			H							
Material of net	Cotton			Cotton			Cotton							
Date	F_i	F_iX_i	F_if	G_i	G_iX_i	G_ig	H_i	H_iX_i	H_ih	$\sum$	$\overline{X}_i$	$(X_i)^2$	X_i	$\overline{X}_i - X_i$
	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$	Kan	Kan	Kan	$\times 10^5$	Kan	
June 2	600	2.8	365				110	0.5	98	3290	470	2.2	437	− 33
3				1600	19.9	1200	1200	14.9	1070	9930	1241	15.4	1260	+ 19
4	1100	6.3	670	100	0.6	75	410	2.4	365	4610	576	3.3	521	− 55
5	400	2.8	244	400	2.8	300	1310	7.2	1160	5610	701	4.9	736	+ 35
6	200	1.4	122	700	5.1	525	720	5.2	640	5770	721	5.2	680	− 41
7	80	0.2	48	180	0.4	135	80	1.6	71	1680	210	0.4	207	− 3
8	150	0.5	92	600	2.2	450	1200	4.4	1070	2970	371	1.4	303	− 68
9	1000	8.2	610	200	1.6	150	500	4.1	445	6600	825	6.8	765	− 60
10	700	12.0	427	900	15.4	675	700	12.0	625	13700	1710	29.3	1820	+ 90
11	500	5.8	305	1400	16.3	1050	2500	29.2	2230	9320	1165	13.6	1125	− 40
12	400	3.5	244	1000	8.8	750	400	3.5	356	6570	881	7.8	735	−156
13	900	11.2	550	800	10.0	600	600	7.6	535	10450	1256	15.8	1520	+276
15	800	7.8	498	200	1.9	150	800	7.8	713	7800	975	9.5	920	− 55
16	1300	22.6	795	1500	26.0	1130	2100	36.5	1870	13900	1737	30.0	1770	+ 37
17	600	5.5	366	800	7.4	600	500	4.6	445	7400	925	8.6	890	− 35
19										4200	1050	11.0	970	− 80
22	1100	6.8	670	600	3.7	450	580	3.6	516	4960	620	3.7	610	− 10
23	300	1.4	183	1000	4.8	750	700	3.4	624	3840	480	2.3	398	− 92
26	700	3.3	427	300	1.4	225	150	7.0	134	3750	468	2.2	426	− 42
28										3850	770	5.9	685	− 85
30	300	3.4	183	200	2.3	150	200	2.3	178	9200	1150	13.3	1420	+270
Total	11130	105.6		12480	130.7		14760	158.7			18402			−855
Relative value	105.6/171.5=0.61			130.7/173.7=0.75			158.7/175.9=0.89							+727

However, it is annoying to solve these simulataneous equations and then to ask for X_1, X_2,....respectively, and a, b,....respectively, so that, a simple solution like the following is adopted. The average catch for each fleet operated in the day i is denoted by $\bar{X}i$ as a substitute for Xi and the values of a, b, ...respectively, are calculated with this value of $\bar{X}i$.

Then with the values of a, b,....respectively, the following equation can be solved;

$$\frac{aAi+bBi+cCi....}{a^2+b^2+c^2....}=\bar{\bar{X}}i$$

If the difference between $\bar{X}i$ and $\bar{\bar{X}}i$ is not too great, the values of a, b, ...respectively, may be recognized as the index of the relative fishing power.

One example of the calculation of this solution is shown in Table 9.

In this calculation, as $\bar{X}i-\bar{\bar{X}}i$ is 727 in total of plus quantity and -855 in total of minus quantity the average value of $\bar{X}i-\bar{\bar{X}}i$ is $\frac{-855+727}{21}=-6$ and the average difference value between plus quantity and minus quantity is $\frac{855+727}{21}=75$.

These values are so small, below -1 per cent and 8.5 per cent respectively, against Xi that they may be neglected. Therefore, the values of a, b,.... respectively, gained with this calculation may be indicated directly the relative fishing power among each fleet.

2) *The method of measurement of the fishing power when the fleet are fishing in different place and time.*

When many fleets are fishing mutually in different fishing-grounds and in different time and some fleets which are the subject of investigation are included in them, the relative fishing power of these fleets may be obtained by means of the least square similar to Method 1) as follow;

If the catch of the standard fleet operated in the fishing-ground j and the month i is denoted by Xij and the average catch per fleet in the month i in every fishing-ground is denoted Si, Si is indicated by the following equation:—

$$Si=\frac{1}{n}\sum_j Xij \qquad (n: \text{ Number of fishing-ground})$$

Then, when the index of productivity in the fishing-ground j through every month is indicated by Gj, the following equation can be formed by means of the least square.

$$\frac{\partial}{\partial Gj}\sum(Xij-GjSi)^2=0$$

$$\text{therefore,} \quad Gj=\frac{\sum_i XijSi}{\sum_i Si^2}$$

Let Aij be the catch of the fleet A in the month i and the fishing-ground j, the relative fishing power of the fleet A is calculated as follows:—

Table 10. One example of the calculation of the relative fishing power when the fleets are fishing in different place and time. (on the fleets in Nagasaki Prefecture, see VII, § 1).

Fishing-ground	Azuchi-Ōshima		Sakai		Hamada		Kenjima		Okinoshima		Tsushima		Shirase	
Month	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i
Jan.	Kan 1631	$\times 10^5$ 60.8	Kan 2542	$\times 10^5$ 95.0	Kan	$\times 10^5$	Kan 3105	$\times 10^5$ 116.0	Kan 7337	$\times 10^5$ 273.0	Kan (10499) 3308	$\times 10^5$ 123.3	Kan 2804	$\times 10^5$ 104.8
Feb.							2227	48.3	3898	82.7	(2740) 2240	47.7	1245	26.5
Mar.					1631	41.2	482	12.3	(460) 1068	26.7	(870) 1470	37.1	2120	53.5
Apr.			2579	67.6	1385	36.4	1450	38.2	1415	37.2	1675	44.0	(242) 1350	35.5
May	2870	60.0	1826	38.2	1934	40.4	560	11.7	2756	57.5	4040	84.5	2280	47.7
June	1820	32.6	2315	41.4	790	14.2	1523	27.3	(3650) 3180	56.0	1470	26.4	1980	35.5
July	(558) 1248	27.5	1391	30.7	1185	26.2	1770	39.0	(1990) 2530	55.8	4480	98.7	904	19.9
Aug.	(328) 1193	33.9	1802	51.4			1244	35.4	2585	73.5	(3160) 2330	66.3	9450	269.0
Sept.	491	11.8	2138	51.3	3061	73.6	3480	83.6	2190	52.7	(3520) 2820	67.8	3090	74.3
Oct.	1200	31.5	2367	67.0	3929	106.0	3830	100.5	3615	95.0	(2184) 2208	58.0	(3206) 3580	94.0
Nov.	970	29.1	3412	102.5	2392	71.8	3250	97.5	3950	118.5	1668	50.0	(3560) 3510	105.7
Dec.			850	35.5			4880	204.0	(3867) 6219	263.0	(5320) 5650	236.0	3490	183.5
Total		287.2		575.6		409.8		813.9		1191.3		939.8		1049.9
G_j	287.2/560.6 =0.51		575.6/813.6 =0.71		409.8/473.9 =0.86		813.9/913.8 =0.89		1191.3/913.8 =1.15		706.8/913.8 =0.78		1049.9/913.8 =1.15	

Table 10. (Continued)

Fishing-ground	Gotō		Amakusa		Satsunan				
Month	X_i	X_iS_i	X_i	X_iS_i	X_i	X_iS_i	$\sum S_i$	S_i	$(S_i)^2$
	Kan	$\times 10^5$	Kan	$\times 10^5$	Kan	$\times 10^5$	Kan	Kan	$\times 10^5$
Jan.	2208	82.3	7552	282.0	3136	116.5	33623	3736	138.5
Feb.	1772	36.6	323	6.8	3256	69.2	14961	2137	45.4
Mar.	1610	40.6	(604) 8410	212.0	3390	85.5	20181	2522	63.8
Apr.	(1742) 1510	39.7	8910	234.2	3459	90.5	23733	2637	69.0
May	1055	22.0	1915	40.0	1669	34.8	20905	2090	43.6
June	1450	26.0	1965	35.2	1424	25.5	17917	1791	32.0
July	1340	29.5	5040	111.0			19888	2209	48.5
Aug.	1950	55.5			2307	65.8	22861	2857	81.0
Sept.	1970	47.4			2447	58.7	21687	2409	57.8
Oct.	3200	84.0	670	17.6	1770	46.5	26369	2636	69.0
Nov.	(5128) 3640	109.2			4320	129.0	27112	3012	90.2
Dec.	3210	134.0			4087	171.0	29286	4183	175.0
Total		706.8		938.8		893.0			913.8
G_j	706.8/913.8 =0.78		938.8/509.8 =1.74		893.0/865.3 =1.03				

Note; ( ): Catch per one day of the Fleet A.

$$
\begin{aligned}
&2209\times0.51\times\ 558 && (2209\times0.51)^2\\
&2857\times0.51\times\ 328 && (2857\times0.51)^2\\
&3736\times1.30\times\ 484 && (3736\times1.30)^2\\
&2522\times1.30\times\ 460 && (2522\times1.30)^2\\
&1791\times1.30\times\ 3650 && (1791\times1.30)^2\\
&2209\times1.30\times\ 1990 && (2209\times1.30)^2\\
&4183\times1.30\times\ 3867 && (4183\times1.30)^2\\
&3736\times1.03\times10497 && (3736\times1.03)^2 \quad = \frac{182099\times10^3}{208040\times10^3}\\
&2137\times1.03\times\ 2740 && (2137\times1.03)^2\\
&2522\times1.03\times\ 870 && (2522\times1.03)^2\\
&2857\times1.03\times\ 3520 && (2857\times1.03)^2\\
&2409\times1.03\times\ 2184 && (2409\times1.03)^2 \quad =0.87\\
&4183\times1.03\times\ 5320 && (4183\times1.03)^2\\
&2637\times1.15\times\ 242 && (2637\times1.15)^2\\
&2636\times1.15\times\ 3206 && (2636\times1.15)^2\\
&3012\times1.15\times\ 3560 && (3012\times1.15)^2\\
&2637\times0.78\times\ 1742 && (2637\times0.78)^2\\
&3012\times0.78\times\ 5128 && (3012\times0.78)^2\\
&2522\times1.74\times\ 604 && (2522\times1.44)^2
\end{aligned}
$$

Namely, the relative fishing power of the Fleet A is 0.87.

$$\frac{\partial}{\partial a}\sum\sum(Aij-aGiSi)^2=0$$

$$\text{therefore,}\quad a=\frac{\sum_i\sum_j AijGjSi}{\sum_i\sum_j Gi^2Si^2}$$

An example of the calculation of this method is illustrated in Table 10.

3) *The method of the estimation of the fishing-rate from the variation of monthly catch in a year.*

When the number of fish in a fishing-ground in a certain month (t) is denoted by S and the number of fish coming into the fishing-ground per month and outgoing from the fishing-ground per month are denoted by I and O, respectively, and the decreasing-rate of fish population per month by fishing and other causes is indicated by ϕ, the following relation may be obtained:—

$$\frac{ds}{dt}=I-O-\phi S \qquad \cdots\cdots\cdots(1)$$

If S is shown to the accompanying formula,

$$S=a+b\cos\left(\frac{\pi}{6}t+\varepsilon_1\right)+c\cos\left(\frac{\pi}{3}t+\varepsilon_2\right) \qquad \cdots\cdots\cdots(2)$$

from (1) and (2) the following expression is obtained:—

$$I-O=a\phi+b\sqrt{\phi^2+\left(\frac{\pi}{6}\right)^2}\cos\left(\frac{\pi}{6}t+\varepsilon_1+\beta\right)$$
$$+c\sqrt{\phi^2+\left(\frac{\pi}{3}\right)^2}\cos\left(\frac{\pi}{3}+\varepsilon_2+\gamma_2\right) \qquad \cdots\cdots\cdots(3)$$

here,

$$\tan\beta=\frac{\pi}{6\phi},\quad \tan\gamma=\frac{\pi}{3\phi}$$

When the fishing-ground is wide enough, it may be assumed that shoals are coming into the inner part of the fishing-ground with the changing of the fishing season to full and after a stay here in certain terms, they are going out from the fishing-ground.

If such removal of shoals would be judged as similar to the composition of the following three items by the formula (3),

1) Certain quantities of fish are coming into the fishing-ground every month,
2) Shoals are incoming and outgoing with yearly cycle,
3) Shoals are incoming and outgoing with half yearly cycle,

the decreasing-rate of the fish population per month ϕ on the average through a year is obtained as follows.

The number of fish coming in the fishing-ground in a year is expressed by

$$12a\phi+2b\sqrt{\phi^2+\left(\frac{6}{\pi}\right)^2+1}\quad+4c\sqrt{\phi^2\left(\frac{3}{\pi}\right)^2+1}$$

and if they are staying in the fishing-ground during T month on the average

through a year, total number of fish in the fishing-ground in a year is possible to be estimated as the following equation,

$$\left[12a\phi+2b\sqrt{\phi^2\left(\frac{6}{\pi}\right)^2+1}\ +4c\sqrt{\phi^2\left(\frac{3}{\pi}\right)^2+1}\right]\times 1/2[1+(1-\phi)^T]\times T$$

and also this is equal to 12a.

Therefore, if $\phi^2<1$

$$[12a\phi+2b+4c]\times T/2[1+(1-\phi)^T]=12a \qquad \cdots\cdots\cdots(4)$$

let $$\frac{2b+4c}{a}=K$$

$$\frac{1}{T/2\times[1+(1-\phi)^T]}=\phi+\frac{K}{12}$$

Coefficients a, b and c are calculated, respectively, as describe later on and k is also obtained from a, b and c, ϕ and r are obtained from formula (4) and yearly decreasing-rate of fish population $r=[1-(1-\phi)^T]$.

Concerning T (staying period of fish), Tauti[41] estimated that the staying period of sardine (T) in a fishing-ground is the shortest time to gain three quarter of the yearly catch during the full fishing season.

The method of the calculation on coefficients a, b and c is described as follows and an example of the calculation by this method is shown in Table 11.

Formula (2) is rewritten as following.

$$S=A_0+A_1\cos\left(\frac{\pi}{6}t\right)+A_2\cos\left(\frac{\pi}{3}t\right)+B_1\sin\left(\frac{\pi}{6}t\right)+B_2\sin\left(\frac{\pi}{3}t\right) \qquad \cdots\cdots(1)'$$

here,
$$\left.\begin{aligned} a&=A_0\\ b\cos\varepsilon_1&=A_1\,,\quad \beta\sin\varepsilon_1=B_1\\ c\cos\varepsilon_2&=A_2\,,\quad c\sin\varepsilon_2=B_2\end{aligned}\right\} \qquad \cdots\cdots\cdots(I)$$

With the method of the least square A_0, A_1, A_2, B_1 and B_2 may be decided so as to be satisfy the following equations,

$$\phi-\sum_{t=0}^{n-1}\left[St-A_0-A_1\cos\frac{\pi}{6}t-A_2\cos\left(\frac{\pi}{3}t\right)-B_1\sin\left(\frac{\pi}{6}t\right)-B_2\sin\left(\frac{\pi}{3}t\right)\right]^2 \qquad \cdots\cdots\cdots(2)'$$

$$\frac{\partial\phi}{\partial A_0}=0,\quad \frac{\partial\phi}{\partial A_1}=0,\quad \frac{\partial\phi}{\partial A_2}=0,\quad \frac{\partial\phi}{2B_1}=0,\quad \frac{\partial\phi}{2B_2}=0$$

namely,

$$\frac{\partial\phi}{\partial A_0}=-2\sum_{t=0}^{n-1}\left[St-A_0-A_1\cos\frac{\pi}{6}t-A_2\cos\left(\frac{\pi}{3}t\right)-B_1\sin\left(\frac{\pi}{6}t\right)-B_2\sin\left(\frac{\pi}{3}t\right)\right]=0$$

$$\frac{\partial\phi}{\partial A_1}=-2\sum_{t=0}^{n-1}\left[St\cos\frac{\pi}{6}t-A_0\cos\frac{\pi}{6}t-A_1\cos^2\frac{\pi}{6}t-A_2\cos\frac{\pi}{3}t\cos\frac{\pi}{6}t-B_1\sin\left(\frac{\pi}{6}t\right)\cos\left(\frac{\pi}{6}t\right)-B_2\sin\left(\frac{\pi}{3}t\right)\cos\left(\frac{\pi}{6}t\right)\right]=0$$

$$\frac{\partial\phi}{\partial A_2}=-2\sum_{t=0}^{n-1}\Big[St\cos\frac{\pi}{3}t-A_0\cos\frac{\pi}{3}t-A_1\cos\frac{\pi}{6}t\cos\frac{\pi}{3}t-A_2\cos^2\frac{\pi}{3}t$$
$$-B_1\cos\frac{\pi}{3}t\sin\frac{\pi}{6}t-B_2\cos\frac{\pi}{3}t\sin\frac{\pi}{3}t\Big]=0$$
$$\frac{\partial\phi}{\partial B_1}=-2\sum_{t=0}^{n-1}\Big[St\sin\frac{\pi}{6}t-A_0\sin\frac{\pi}{6}t-A_1\cos\frac{\pi}{6}t\sin\frac{\pi}{6}t$$
$$-A_2\cos\frac{\pi}{3}t.\sin\frac{\pi}{6}t-B_1\sin^2\Big(\frac{\pi}{6}t\Big)-B_2\sin\frac{\pi}{6}t\sin\frac{\pi}{3}t\Big]=0$$
$$\frac{\partial\phi}{\partial B_2}=-2\sum_{t=0}^{n-1}\Big[St\sin\frac{\pi}{3}t-A_0\sin\frac{\pi}{6}t-A_1\cos\Big(\frac{\pi}{6}t\Big)\sin\frac{\pi}{3}t$$
$$-A_2\cos\frac{\pi}{3}t\sin\frac{\pi}{3}t-B_1\sin\frac{\pi}{6}t\sin\frac{\pi}{3}t-B_2\sin\frac{\pi}{3}t\Big]=0$$

and

$$A_0=\frac{1}{12}\sum_{t=0}^{n-1}St$$
$$A_1=\frac{1}{6}\sum_{t=0}^{n=1}St\cos\frac{\pi}{6}t$$
$$A_2=\frac{1}{6}\sum_{t=0}^{n-1}St\cos\frac{\pi}{3}t$$
$$B_1=\frac{1}{6}\sum_{t=0}^{n-1}St\sin\frac{\pi}{6}t$$
$$B_2=\sum_{t=0}^{n-1}St\sin\frac{\pi}{3}t$$

From (I)

$$\boldsymbol{a}=\boldsymbol{A}_0$$
$$(b\cos\varepsilon_1)^2+(b\sin\varepsilon_1)^2=A_1^2+B_1^2$$
$$\therefore\quad \boldsymbol{b}^2=\boldsymbol{A}_1^2+\boldsymbol{B}_1^2$$
$$(c\cos\varepsilon_2)^2+(c\cos\varepsilon_2)^2=A_2^2+B_2^2$$
$$\therefore\quad \boldsymbol{c}^2=\boldsymbol{A}_1^2+\boldsymbol{B}_2^2$$

Table 11. One example of the calculation of the fishing rate from the variation of monthly catches in a year.
(on anchovy purse seine fleets at Katagai in Chiba Prefecture, see, VII. § 2)

Month	Catch per fleet	Three month average of the left value	Calculated value of the formula	$St\cdot\cos\pi/6\cdot t$	$St\cdot\sin\pi/6\cdot t$	$St\cdot\cos\pi/3\cdot t$	$St\cdot\sin\pi/3\cdot t$
	Kan	Kan	Kan				
1950 Aug.	400	430	430	430	0	430	0
Sep.	600	640	640	555	320	320	550
Oct.	930	950	950	475	825	− 475	820
Nov.	1320	1340	1340	0	1340	−1340	0
Dec.	1780	1650	1650	− 825	1430	− 825	−1420
1951 Jan.	1860	1790	1790	−1560	895	895	−1550
Feb.	1730	1650	1680	−1680	0	1685	0
Mar.	1360	1590	1600	−1390	− 800	800	1390

Apr.	1680	1270	1270	− 635	−1100	− 635	1110
May	780	1170	1040	0	−1040	−1040	0
June	1040	790	900	450	− 780	− 450	− 780
July	550	730	700	640	− 370	370	− 640
	14030		14030 (a)	−3540 (A_1)	− 720 (B_1)	− 265 (A_2)	− 520 (B_2)

$$a=\frac{14030}{12}=1170 \qquad b=\sqrt{\left(\frac{-3540}{6}\right)^2+\left(\frac{720}{6}\right)^2}=602 \qquad c=\sqrt{\left(\frac{-265}{0}\right)^2+\left(\frac{-520}{6}\right)^2}=96$$

$$K=\frac{2b+4c}{a}=\frac{2\times602+4\times96}{1170}=\frac{1588}{1170}=1.35$$

$$\frac{K}{12}=0.112$$

The staying period of anchovy in a fishing-ground is estimated af follows,

$$14030\ \text{kan}\times3/4=10{,}500\ \text{kan}$$

The shortest period to gain 10,500 kan in the fishing season is 7.2 monthes during Oct., 1950 to May, 1951.

ϕ	$\frac{7.2}{2}\times[1+(1-\phi)^{7.2}[^{\frac{1}{}}-\phi$
0.05	0.115
0.07	0.114

$\therefore\ \phi=0.05\times0.2\times3/11=0.055$

4) *The method of estimation of the decreasing-rate from the variation of the unit catch in a certain time.*

When a shoal is passing through a fishing-ground without any scattering and entering fish, the fishing-rate of the shoal in a certain time is estimated by the following method.

When the shoal is passing through with velocity v along X axis (Fig. 15) the amount of fish at t time on a plan being perpendicular to X aris is indicate by $(x-vt)$.

Then, the amount of fish at x point may be apparently increased with the rate $\frac{-vf'(x-vt)}{f(x-vt)}$ owing to the removing of the shoal.

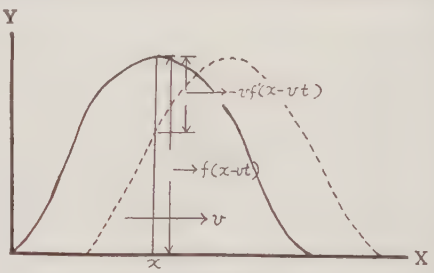


Fig. 15.

In this case, if the shoal decreased by the constant rate f (f is explained later on) passing through a perpendicular plane to x point the amount of fish at x point may be increased with the increasing-rate

$$-\frac{vf'(x-vt)}{f(x-vt)}-f.$$

Therefore, the average increasing-rate during the period from t_1 to t_2 (Fig. 16) can

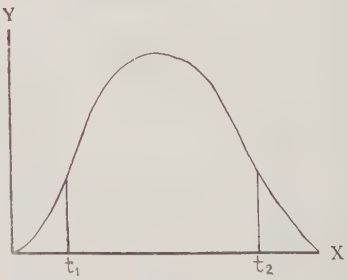


Fig. 16.

be expressed by

$$\frac{1}{t_2-t_1}\int_{t_1}^{t_2}-\left(v\frac{f'(x-vt)}{f(x-vt)}+f\right)dt=\frac{1}{t_2-t_1}\left[\ln\frac{f(x-vt_2)}{f(x-vt_1)}-f\right]$$

because,

$$f=-[\text{the average increasing-rate}]+\frac{1}{t_2-t_1}\left[\ln\frac{f(x-vt_2)}{f(x-vt_1)}-f\right]$$

If the amount of fish is expressed in unit of weight, f is explained as the following equation:

$$f=f_0+e+d-g$$

f_0: fishing-rate
e: diminishing-rate by superior predator
d: natural mortality
g: growing-rate of fish in weight

If the sampling of data is carried out on each day, d and e may be negligible, but g should be considered some species of fish which the growing in a day is considerably great.

An example of the calculation of this method is shown in Table 12.

Table 12. One example of the calculation of diminishing-rate per day.
(on the fleets at Katagai in Chiba Prefecture, see, VII. § 3, Table 31.)

Date	Catch per fleet and day (Kan)	Increasing-rate		Diminishing-rate		Date	Catch per fleet and day (Kan)	Increasing-rate		Diminishing-rate	
Jan. 3	540					Apr. 23	2350				
4	4300	3760/2420	1.551			28	1430				
5	480			3820/2390	1.60	29	5500				
8	4300					30	1800				
12	2350					July 1	5230				
13	6200	3850/4275	0.901			2	2420				
14	2080			4120/4140	0.995	3	140				
15	2890					8	2670				
17	50					9	2180				
19	3550					11	800				
20	3340					12	2670	1870/1735	1.077		
23	2550					13	780			1890/1725	1.095
25	200					Aug. 6	4450				
29	710					7	1370				
Apr. 3	1090					8	1930				
4	3960	2870/2525	1.135			9	2830				
5	3080			880/3520	0.250	10	915				
6	4250	1170/3665	0.319			11	1590	675/1252	0.538		
7	1650			2600/2950	0.880	12	830			760/1210	0.680
8	980			670/1315	0.516	16	4400				
11	900					17	5200				
22	1390					19	2140				

Table 12. (Continued)

Date	Catch per fleet and day (Kan)	Increasing-rate		Diminishing-rate	
Aug. 20	230				
24	580				
Oct. 16	1990				
17	1030				
21	530				
22	2830	2300/1680	1.370		
23	500			2300/1665	1.40
30	750				
31	2760	2010/1755	1.145		
Nov. 1	1010			1750/1885	0.930
2	700			310/ 855	0.363
4	210				
5	1150	1940/ 680	1.380		
6	970			180/1060	0.170
7	270				
11	620				
13	1160				
14	430				
15	510				
20	710				
24	250				
25	50				

Date	Catch per fleet and day (Kan)	Increasing-rate		Diminishing-rate	
Dec. 2	2760				
3	920				
4	340				
5	560				
6	4620				
7	5450				
8	18500				
9	1250				
10	2000				
11	3700	1700/2850	0.597		
12	4790	1090/4245	0.257		
13	3760			1030/4275	0.242
14	1970			1790/2865	0.625
15	14500				
19	5320				
22	1200				
23	9950	8750/5575	1.570		
24	4550			5400/7250	0.745
25	1900			2650/3225	0.825
26	2900				
31	5730				

Table 12. (Continued)

$$-\frac{1.551-1.600}{2}+\frac{1}{2}ln\frac{480}{540}=\frac{1}{2}(0.049-0.012)=\frac{0.037}{2}$$

$$-\frac{0.901-0.995}{2}+\frac{1}{2}ln\frac{2080}{2350}=\frac{1}{2}(0.094-0.122)=-\frac{0.028}{2}$$

$$-\frac{1.454-1.650}{5}+\frac{1}{5}ln\frac{980}{1090}=\frac{1}{5}(0.184-0.083)=\frac{0.101}{5}$$

$$-\frac{1.175-0.925}{2}+\frac{1}{2}ln\frac{2030}{1439}=\frac{1}{2}(-0.250+0.350)=\frac{0.100}{2}$$

$$-\frac{1.077-1.095}{2}+\frac{1}{2}ln\frac{780}{800}=\frac{1}{2}(0.018-0.028)=\frac{-0.010}{2}$$

$$-\frac{0.538-0.630}{2}+\frac{1}{2}ln\frac{830}{915}=\frac{1}{2}(0.092-0.097)=-\frac{0.005}{2}$$

$$-\frac{1.370-1.400}{2}+\frac{1}{2}ln\frac{500}{530}=\frac{1}{2}(0.030-0.060)=\frac{-0.030}{2}$$

$$-\frac{1.145-1.293}{3}+\frac{1}{3}ln\frac{700}{750}=\frac{1}{3}(0.148-0.069)=\frac{0.079}{3}$$

$$-\frac{1.380-1.300}{3}+\frac{1}{3}ln\frac{270}{210}=\frac{1}{3}(-0.080+0.251)=\frac{0.171}{3}$$

$$-\frac{0.854-0.867}{4}+\frac{1}{4}ln\frac{1970}{2000}=\frac{1}{4}(0.013-0.016)=\frac{-0.003}{4}$$

$$-\frac{1.570-1.570}{3}+\frac{1}{3}ln\frac{1900}{1200}=\frac{1}{3}(-0.000+0.458)=\frac{0.458}{3}$$

$$\frac{0.946-0.076}{30}=\frac{0.876}{30}=0.029$$

therefore, $f=0.029$

VI. The Fishing Power of the Purse Seine Fleets for Anchovy

Anchovy is one of the most abundant and important fish in our country and they are caught on the whole of our land, especially on the coast of Chiba Prefecture and Kyushū Region.

In this Chapter, anchovy purse seine fleets based on the coast of Chiba Prefecture and the neighbouring Kanagawa Prefectures were mainly investigated in regard to the problem of fishing power from seven points of view as mentioned below.

§ 1. The Fishing Power of the Purse Seine Fleets in Relation to the Tonnage of Boats and Materials of Nets

At a time when the purse seine fleets based on 10 stations at Chiba and Kanagawa Prefectures were operating in the same time and same place the fishing power of the fleets in relation to the tonnage of boats and materials of nets was investigated from the data related to the catch per day, the number of pursing and the catch per pursing.

Data

The stations where investigations were carried out are illustrated in Fig. 17. The data for the investigation are catch per day and the number of pursing per day for each fleet, which were collected from the fisheries cooperative

associations in each station as shown in Fig. 17 except Tateyama, Hoda and Sajima in which the data were collected from each Branch Office of Statistics and Survey Division of the Agriculture-Forestry Economic Bureau.

The elements of the purse seine fleets in each station as shown in Tables 13 to 20 and 22 to 25, respectively, were collected by the author's herring-research from fishermen.

Viewing in detail these tables, in many cases there are differences not only in tonnage of seiners but also in the kind of materials of nets among each fleet in a station. For example, on the Toyoumi fleets (Table 15) the tonnage of Fleet *A* is 6.8 tons and the kind of material of the net is cotton, but other fleets are almost about 19 tons in tonnage of seiner and the kind of material of the net of Fleet *C* and *D* are Cremona (Vinylon). Therefore, in the case of investigation on the effect of the difference in tonnage of seiner on the fishing power, we have to notice so as to take off the effect of the difference of the material of nets on fishing power. Such a consideration was given carefully into under the investigation.

In this study, Method 1) was employed as the means of calculation of the fishing power and the relative value for the catch per day, the number of pursing per day and catch per pursing for each fleet were obtained as shown in Tables 13~20 and 22~25, respectively. On the Kamogawa, Tateyama, Hoda, and the Sajima fleets, as the mean number of pursing were net calculated because there were no data, the mean numbers of pursing per day was used as an index of the fishing power.

Fig. 17. Position of the stations where investigations were carried out along the coasts of Chiba and Kanagawa Prefectures.

Results

a. Effect of the difference in tonnage of seiner on the fishing power.

The difference on fishing power for each fleet among the Katagai fleets are shown in Table 13. From this table it is clear that the respective relative values are 0.84 to 1.07 for the catch per day, 0.91 to 1.14 for the number of pursing and 0.93 to 1.17 for the catch per pursing. It is difficult to explain the variation in the relative values of the mentioned items, because there is no remarkable difference in the tonnage of the seiner of the Katagai fleets and also no noteworthly difference exists in the size of the net, the number of the crew nor in the kind of fish finder.

On the Hota fleets as shown in Table 14 it is also similar to the results

of the Katagai fleets. The relative value for the catch per day is 0.87 to 1.19 in May to July, 1953 and also there is little material difference in the tonnage of the seiner and the size of the net among them.

Generally, in Chiba Prefecture, the purse seine fleets may be classified two types according to the tonnage of the seiner as shown in Table 15 (the Toyoumi fleets), Table 16 (the Sakae fleets), Table 17 (the Kamogawa fleets) and Table 18 (Tateyama fleets), namely, 4–7 tons class and about 20 or more tons class. In the former class, a crew of 20–40 men utilize from 1 to 2 fish finders and use a seine of 118–140 metres in length and 30–35 strips* in depth. However, in the later class, a crew of 50–60 men utilize 2 or 3 fish finders and use a seine of 172–218 metres in length and 55–85 strips in depth.

Accordingly, it is reasonable to discuss the fishing effect of the tonnage of the seine boats, the size of nets separately as shown these tables. Thus, although there is no significant difference between the two classes in the number of pursing in each day, it is remarkable that the catch per pursing of 20 or more tons class is 1.4–2.3 times greater than that of 4–7 tons class. Table 19 and 20 show, respectively, the case of small difference exists in the tonnage of seiner, such as less 20 tons class (15.5–19.9 tons) and more 20 tons class (23.5–27.1 tons) among the Ōhara fleets and less 15 tons class (14.6 tons) and more tons class (16.5–19.9 tons) among Sajima fleets.

On the Ōhara fleets, Fleet D and G are smaller in the tonnage of seiner than the other and the relative values of them for the catch per day are also less than these of others. On the Sajima fleets, it is similar to the result on the Ōhara fleets.

Thus, Table 21 shows the synthetic result putting together Tables 13 to

Table 21. Relation between the relative value for the catch per day and the tonnage of seiner

Fishing base	Tonnage of seiner (ton)		Relative value for the catch per day	
	Small tonnage class	Large tonnage class	Small tonnage class	Large tonnage class
Katagai	—	18.0~19.7	—	0.84~1.07
Hota	—	18.5~19.0	—	0.87~1.19
Sakae	4.8	19.5~19.8	0.48	1.06~1.38
Toyoumi (Jan.~May, Oct.~Dec., 1953)	6.8	19.0~19.8	0.53	1.10~1.20
Ōhara	15.5~19.9	23.5~27.1	0.62~0.78	0.93~1.27
Kamogawa	6.3~6.5	25.5	0.64~0.82	0.97
Tateyama (Nov. Dec., 1953)	4.5	16.0~19.0	0.61	0.99~1.04
Sajima	14.6	16.5~19.0	0.70	0.92~1.35

20. From this table it may be said that if there is no significant difference in the tonnage of seiner and the size of net among each fleet such as the Katagai and the Hoda fleets there is also no remarkable difference in the fishing power.

* One strip contains 100 full meshes deep.

And if there is a remarkable difference in the tonnage of seiner such as the Sakae, Toyumi. Kamogawa and the Tateyama fleets noteworthy difference exists in the fishing power. Generally, the size of the nets is in proportion to the tonnage of seiner as shown in Fig.18.

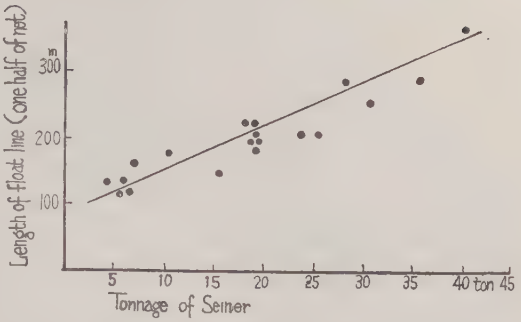


Fig. 18. Relation between length of float line and tonnage of seiner.

b. Effect of the difference of material of nets on fishing power.

Following Tables 15 (the Toyoumi fleets) and 19 (the Ōhara fleets) both Fleet C at Toyumi and Fleet A at Ōhara use Cremona (Vinylon) net and Amillon (Nylon) net, respectively, but there is no remarkable difference in the relative values for the catch per day, the number of pursing per day and the catch per pursing compared with the fleets which use cotton nets. (In here, the mixed net with synthetic fiber net and cotton net is regarded as cotton net).

Owing to the synthetic fiber net such as Kanebian (Vinylon), Cremona (Vinylon), Amillon (Nylon) and Marlon (the mixed thread with Cremona and Amillon) need not be dried for preservation, their daily use is advantage over which require drying for preservation. However, such advantage was contary to the results, because there was found no remarkable difference in the number of pursing per day between the fleets which used synthetic fiber nets and used cotton nets. And such result was also gained from Table 22, 23 and 24.

These tables show the month when each fleet exchanged the material of nets from cotton net to synthetic fiber net with a mark of *.

But it is not recognized that the fleets which have changed to synthetic fiber net always show higher relative values than the fleets which have not exchanged yet to synthetic fiber net.

While, following Table 17 (the Kamogawa fleets) it must be noticed that Fleet B which use cotton net shows a little smaller value for the catch per day than Fleets A and C which have been exchange already to Amillon (Nylon) net. In this case, as the mean number of pursing per day of Fleet B is recognizably less than those of Fleet A and C, the difference of the relative value for the catch per day may be decided owing to the number of pursing, in the same way as the Kamogawa fleets.

On the Sakae fleets (Table 25), there is a remarkable difference between Fleets B and F which use synthetic fiber nets and Fleets C, D and E which use cotton nets in the relative value for the catch per day and the number of pursing as shown in Table 12. And such result is shown on the Tateyama fleets (Table 18) and the Hota fleets (Table 14), too.

These results obtained were arranged summarily as shown in Table 26.

Table 26. Comparison of the relative value for the catch per day between the boats which used cotton net and used synthetic fiber net.

Fishing base		Tonnage of seiner		Relative value for the catch yer day	
		The boat which used cotton net	The boat which used synthetic fiber net	The boat which used cotton net	The boat which used synthetic fiber net
		tons	tons		
Hota		18.9~19.6	18.5	0.84~0.97	1.26
Toyoumi	(Jan.-Mar. Oct.-Dec., 1953)	19.0	19.0~19.8	1.17	1.10~1.20
Ōhara	(Nov., 1952~ Apr., 1953)	23,5~27.1	25.5	0.93~1.27	1.31
Kamogawa		25.5	23.0~27.5	0.97	1.37~1.39
Tateyama	(May-July,1953)	15.5~19.0	17.8~19.9	0.80~0.98	0.88~1.28
〃	(Nov.-Dec., 1953)	〃	〃	0.99~1.04	0.93~1.38
Sakae	(Dct.-Dec., 1954)	19.0~19.8	17.3~19.6	0.81~1.28	1.01~1.79

According to this table the effect of the difference of material of nets on fishing power differ with each station, namely, on the Katagai, Toyoumi and the Ōhara fleets no remarkable difference in the fishing power can be found among each fleet but on the Kamogawa, Tateyama, Hoda and the Sakae fleets it will be recognized that the fishing power of the fleets which use synthetic fiber nets is superior to that of the fleets which use cotton nets.

Table 13. The Katagai fleets. Elements of the purse seine fleets and its relative value on fishing.

Fleet		A	B	C	D	E	F	G
Tonnage of seiner (ton)		19.7	19.7	19.7	19.6	19.2	18.0	19.5
Horse power of engine (HP)		50	45	50	55	50	40	50
Material of net		Cotton	〃	〃	〃	〃	〃	〃
Length of float line (one half) (m)		202	195	198	192	192	200	198
Mesh size and number of strips*		cm 1.3, 80	1.3, 78	1.3, 80	1.3, 75	1.3, 75	1.3, 78	1.3, 80
Number of fish finder		2	3	3	3	2	3	2
Number of crew		54	54	56	56	58	60	56
Period of investigation		Oct., 1952~Sep., 1953						
Average relative value through the period	Catch per day	1.07	1.07	1.07	1.07	0.84	0.93	0.95
	Number of pursing	1.01	1.14	1.06	1.01	0.91	0.96	0.91
	Catch per pursing	1.04	0.93	1.00	0.99	0.93	1.00	1.17

* A strip has one hundred meshes.

Table 14. The Hota fleets.

I. May~July, 1953

Fleet	A	B	C	D
Tonnage of seiner (ton)	18.5	18.9	19.6	19.0
Horse power of engine (HP)	60	50	40	50
Material of net	Cotton	Cotton	Cotton Cremona	Cotton
Length of float line (m)	192	175	180	175
Mesh size and number of strips	cm 1.3, 85	1.3, 85	1.3, 85	1.3, 85
Number of crew	60	55	56	56
Number of fish finder	1	1	1	1
Relative value for the catch per day	1.19	1.00	0.94	0.87

II. Oct.~Dec., 1953

Material of net	Amillan Cremona	Cremona Cotton	Cremona Cotton	Cotton
Length of float line (m)	195	175	180	175
Mesh size and number of strips	cm 0.9, 90	1.3, 80	1.3, 85	1.3, 80
Relative value for the catch per day	1.26	0.97	0.84	0.93

Table 15. The Toyoumi fleets.

I. Jan.~Mar. and Oct.~Dec., 1953

Fleet		A	B	C	D
Tonnage of seiner (ton)		6.8	19.0	19.0	19.8
Horse power of engine (HP)		12	50	40	65
Material of net		Cotton	Cotton	Cremona	Amillan
Length of float line (m)		118	204	218	204
Mesh size and number of strips		cm 1.5, 65	1.3~1.4, 75	0.9~1.3, 80	0.9~1.3, 80
Number of crew		30	58	60	60
Number of fish finder		2	3	3	3
Relative value	Catch per day	0.53	1.17	1.20	1.10
	Number of pursing	1.01	0.99	1.03	0.97
	Catch per pursing	0.50	1.08	1.19	1.23

II. May~Aug., 1953

Material of net		Cotton	Cotton	Cotton	Cotton
Length of float line (m)		120	180	178	180
Mesh size and number of strips		cm 2.7, 40	2.7, 55	2.7, 60	2.7, 55
Relative value	Catch per day	0.84	0.90	1.37	0.89
	Number of pursing	1.08	0.89	1.01	1.02
	Catch per pursing	0.77	0.92	1.43	0.88

Table 16. The Sakae fleets.

Fleet		A	B	C	D
Tonnage of seiner	(ton)	4.8	19.6	19.8	19.5
Horse power of engine	(HP)	10	40	50	40
Material of net		Cotton	〃	〃	〃
Length of float line	(m)	140	180	183	180
Mesh size and number of strips		cm 1.5, 40	1.5, 58	1.5, 75	1.5, 75
Number of crew		30	50	60	55
Number of fish finder		1	2	2	2
Period of investigation		Nov.~Dec., 1953			
Relative value	Catch per day	0.48	1.38	1.08	1.06
	Number of pursing	1.14	1.07	0.95	0.84
	Catch per pursing	0.40	1.32	0.98	1.30

Table 17. The Kamogawa fleets.

Fleet	A	B	C	D	E	F
Tonnage of seiner (ton)	27.5	25.5	23.0	6.3	6.5	6.3
Horse power of engine (HP)	70	50	40	15	12	13
Material of net	Amillan	Amillan Cremona, Cotton	Amillan Cremona	Cotton	Amillan Cotton	Cotton
Length of float line (m)	17.5	175	170	130	125	127
Mesh size and number of strips	cm 0.9, 85	1.0, 75	1.3~0.9, 79	1.1, 60	1.1, 58	1.1, 60
Number of crew	60	58	60	35	35	34
Number of fish finder	3	3	3	2	2	1
Period of investigation	May~Oct., 1953					
Relative value for the catch per day	1.37	0.97	1.39	0.82	0.81	0.64
Mean number of pursing per day	2.6	2.3	3.1	—	—	—

Table 18. The Tateyama fleets.

I. May~July, 1953

Fleet	A	B	C	D	E	F	G	H	I
Tonnage of seiner (ton)	19.0	19.3	19.3	19.9	17.8	15.5	16.0	19.0	4.5
Horse power of engine (HP)	40	50	80	60	50	4.0	40	50	12
Material of net	Cremona	〃	〃	〃	Kanebian	Cotton	〃	〃	〃
Length of float line (m)	175	180	175	180	175	175	173	175	120
Mesh size and number of strips	cm 1.3, 80	1.2, 80	1.3, 80	1.2, 85	1.3, 80	1.0, 80	1.3, 80	1.3, 75	1.3, 55
Number of crew	55	55	60	60	55	56	55	56	30
Number of fish finder	1	1	1	1	1	1	1	1	1
Relative value for the catch per day	0.95	0.98	1.27	1.28	0.88	0.86	0.80	0.98	-
Mean number of pursing per day	3.5	—	4.0	4.2	0.34	3.5	3.3	—	—

II. Nov.~Dec., 1953

Material of net	Cremona	Cremona	Cremona	Amillan Cremona	Kanebian	Cremona	Cotton	Cotton	Cotton
Length of float line (m)	175	180	175	186	175	175	173	175	120
Mesh size and number of strips	cm 1.3, 80	1.2, 80	1.3, 80	1.2~1.0, 110	1.3, 80	1.0, 80	1.3, 80	1.3, 75	1.3, 55
Relative value for the catch per day	0.97	0.93	1.08	1.38	0.90	1.09	0.99	1.04	0.61
Mean number of pursing per day	2.9	—	3.2	3.2	3.0	3,0	2.9	—	2.3

Table 19. The Ōhara fleets.

Fleet		A	B	C	D	E	F	G	H	I
Tonnage of seiner (ton)		25.5	25.4	25.4	19.9	26.5	23.5	15.5	25.5	27.1
Horse power of engine (HP)		70	70	70	70	80	65	60	90	80
Material of net		Kanebian	Cotton	〃	〃	〃	〃	〃	〃	〃
Length of float line (m)		200	185	195	190	185	190	150	200	195
Mesh size and number of strips		cm 1.3, 80	1.2, 73	1.2, 75	1.3, 75	1.2, 75	1.3, 76	1.2, 65	1.2, 80	1.3, 76
Number of crew		60	60	58	56	58	56	30	60	60
Number of fish finder		3	3	2	2	3	2	1	3	3
Period of investigation		Nov., 1952～Apr., 1953								
Relative value	Catch per day	1.31	0.93	0.93	0.78	1.15	0.96	0.62	1.21	1.27
	Number of pursing	1.14	1.02	1.05	0.98	0.99	0.96	0.79	1.07	1.08
	Catch per pursing	1.15	1.02	1.00	0.73	1.12	0.92	0.71	1.15	1.14

Table 20. The Sajima fleets.

Fleet		A	B	C	D	E	F
Tonnage of seiner	(ton)	16.5	14.6	19.0	17.3	19.9	17.0
Horse power of engine	(HP)	65	50	60	65	80	55
Length of float line	(m)	210	187	210	210	210	220
Number of fish finder		1	1	1	1	1	1
Period of investigation		Jan.～Dec., 1952					
Relative value the catch per day		0.92	0.70	0.98	0.89	1.35	1.16

Table 22. The Katagai fleets.

Fleet		A		B		C		D		F		G	
Tonnage of seiner (ton)		19.7		19.7		19.7		19.6		18.0		19.5	
Material of net		Amillan Marlon Cremona		Amillan Cremona		Amillan Cremona		Amillan Marlon Cremona		Amillan Marlon Cremona		Amillan Marlon Cremona	
Colour of net		Light brown		Light brown Green		Light brown White		Light brown		Light brown		Light brown	
Length of float line (m)		195		195		195		180		190		190	
Mesh size and number of strips		cm 1,4~0.9, 89		1.0, 97		1.2~1.3, 85		0.9, 89		1.0~0.8, 26		1.0, 83	
Period \ Relative value		*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*
Jan.	1954	0.92	0.96	0.77	0.99	1.10	1.11	1.10	1.03	1.10	1.01	1.01	0.90
Feb.		0.99	1.11	1.10	1.04	1.02	1.11	0.81	1.02	1.04	0.84	1.04	0.88
Mar.		0.85	1.07	*1.32	*1.27	0.97	0.93	1.00	0.97	0.71	0.82	1.15	0.94
Apr.		1.16	1.12	1.07	1.12	0.84	1.02	0.92	0.96	0.89	0.81	1.12	0.98
May		1.05	0.89	0.83	1.04	1.13	1.10	1.24	1.04	0.81	1.02	0.94	0.91
June		1.11	0.98	0.91	1.03	1.16	1.11	*1.14	*0.99	0.80	0.91	0.88	0.98
July		1.05	1.13	1.09	0.86	*0.94	*1.10	1.09	1.13	0.82	0.85	1.01	0.93
Aug.		1.01	1.00	0.81	0.99	1.13	1.01	1.15	1.25	*0.84	*0.85	1.06	0.90
Sep.		*1.06	*1.02	1.19	1.06	0.91	1.03	1.11	0.99	0.90	1.01	0.83	0.89
Oct.		0.95	1.08	1.12	0.88	0.89	1.03	1.22	1.12	0.90	1.02	*0.92	*0.87
Nov.		0.87	1.02	1.10	0.99	0.84	0.88	1.10	0.95	0.83	1.09	1.16	1.07
Dec.		1.14	1.03	0.86	0.88	1.15	1.06	1.02	1.15	0.87	0.94	0.96	0.94
Jan.	1955	0.78	1.00	1.11	0.99	0.99	1.07	1.16	1.13	1.12	0.91	0.84	0.90
Average		0.99	1.03	1.03	1.01	1.00	1.04	1.08	1.06	0.90	0.93	1.00	0.93

Note: * : Beginning of the use of synthetic fiber net
F: Relative value for the catch per day
N: Relative value for the number sf pursing per day

Table 23. The Toyoumi fleets.

Fleet	B′		C′		D′		E′	
Tonnage of seiner (ton)	22.0		25.0		23.7		24.0	
Material of net	Cotton		Amillan Marlon		Amillan Cremona		Amilan Cremona Marlon	
Colour of net	Light brown		〃		White (No dressing)		Light brown	
Length of float line (m)	180		200		200		200	
Mesh size and number of strips	cm 1.3, 57		1.2, 84		1.2, 82		1.0, 80	
Relative value / Period	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*
Jan. 1954	0.67	1.03	1.15	1.05	*1.08	*0.91	1.10	1.01
Feb.	0.78	0.91	1.08	0.97	1.13	1.21	1.00	0.91
Mar.	1.20	1.16	0.78	0.83	1.28	1.20	0.74	0.81
Apr.	0.57	0.80	1.28	1.04	1.28	1.15	0.87	1.01
May	0.64		*1.34		1.08		0.94	
June	0.57		1.22		1.18		1.03	
July	0.47		1.42		0.85		1.26	
Aug. Sep.	0.59	0.90	1.18	1.15	1.34	1.06	0.89	0.89
Oct.	0.57	0.80	1.18	1.03	1.05	1.05	*1.20	*1.12
Nov.	0.66	0.76	1.03	1.08	1.02	0.98	1.29	1.18
Dec.	0.57	0.64	1.23	1.17	1.05	1.10	1.15	1.09
Jan. 1955	1.00	1.02	1.23	1.12	0.94	1.04	0.83	0.82
Average	0.69	0.89	1.18	1.05	1.11	1.08	1.02	0.98

Table 24. Ōhara fleets.

Fleet	A	B	C	D	E	F	G	H	I
Tonnage of seiner (ton)	25.5	25.4	25.4	19.9	26.5	23.5	15.5	25.5	27.1
Material of net	Amillan Kanebian	Cremona Amillan Cotton	Amillan Cotton	Cotton	Amillan Cremona	Amillan Cremona Marlon	Cotton	Amillan Cotton	Amillan Cotton
Colour of net	Green	Green Light brown	White Light brown	Light brown	Green	Light brown	〃	〃	〃
Length of float line (m)	200	185	195	190	195	190	195	182	195
Mesh size and number of strips	cm 1.2, 85	1.3, 80	1.1~1.0, 90	1.3, 80	1.0, 88	1.0, 88	1.4, 65	1.1~0.9, 80	1.3~1.0, 84
Relative value	*F*	*F*	*F*	*F*	*F*	*F*	*F*	*F*	*F*
Jan. 1954	* 0.95		1.04	0.90	* 1.15	* 0.88		1.25	* 0.83
Feb.	1.30		1.00	0.77	1.04	0.92		1.21	0.76
Mar.	1.22	0.71	1.11		0.99	1.00		0.97	1.00
Apr.	1.32	0.96	0.96		1.13			0.90	1.00
May	1.08	0.99	1.15	0.88				0.99	0.91
Dec.	0.98	1.04	0.92		1.00	0.88		1.13	1.05

Table 25. The Sakae fleets.

Fleet	B		F		C		D		E		A	
Tonnage of seiner (ton)	19.6		17.3		19.8		19.5		19.0		7.3	
Material of net	Amillan Cremona		Amillan		Amillan Cotton		Cremona Cotton		Cotton		Cremona Cotton	
Length of float line (m)	225		180		210		180		180		165	
Mesh size and number of strips	cm 1.3, 90		1.3, 70		1.3, 81		1.3, 65		1.5~1.3, 75		1.3, 70	
Relative value	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*	*F*	*N*
Mar.~Apr. 1954	1.17	1.40	0.71	0.77	1.03	1.00	1.05	0.89	1.04	0.94		
May	1.21	1.16	1.16	1.20	0.90	0.86	0.94	0.86	0.79	0.92		
June	1.30	0.96	1.09	1.32	0.94	1.11	0.78	0.84	0.89	0.77		
July~Aug.	1.08	1.03	0.82	0.85	0.93	0.90	1.02	1.07	1.15	1.15		
Sep.	1.47	1.30	1.17	1.08	0.86	0.94	0.80	0.94	0.70	0.74		
Oct.	1.75	1.40	0.95	0.92	0.83	0.94	1.01	1.08	0.81	0.92	0.65	0.74
Nov.	2.00	1.38	1.04	1.14	0.84	1.00	0.77	0.90	0.85	0.91	0.50	0.67
Dec.	1.64	1.25	1.04	1.05	1.17	1.06	0.65	0.94	1.03	1.05	0.47	0.65
Jan. 1955	1.47	1.13	1.20	1.12	0.92	0.96	0.69	0.88	0.72	0.91		

§ 2. The Effect of the Fish Finder on the Purse Seine Fishery

Fish finders have been in use since about 1950 in the purse seine fishery and it is evident that the use of them has brought about a great advance in the fishing operation. In this study it has been shown that a large increase in the fishing power of the fleets has resulted from the use of fish finders.

Effect on the searching of fish

As a means of searching for fish during the period when no fish finder was in use fishermen used the methods of sea-surface indications, for example, individual fish jumping out of the water (it is called "Hane" in Japanese) and rippling on the sea-surface (it is called "Seri" in Japanese) and bubbles emitted by fish into the water, the changing colour on the sea-surface by crowded fish, and flying birds above the sea-surface.
And during this period above 90 per cent of the number of shoals detected was mainly made by "Seri" and "Hane".

Since fish finders have come into use, the finding of the fish becomes very easy and certain and even if fishermen locate a shoal by antiquated means such as the indications appeared on the sea-surface they confirm again the existance of the shoal with the fish finder.

It has been acknowledged by the author's reports[42),43)] on the characteristic behaviours of anchovy shoals in Tokyo Bay that to use the fish finder is more favourable on the searching of fish than to depend upon the indication on the sea-surface as "Seri" and "Hane".

Accordingly to Table 27 which is tabulated again from the author's report[43)], the numbers of detected by "Seri" and "Hane" are many at morning and evening than at day-time.

This result would satisfy us on the fact that during the periods when fish finders were not in use the operation of the purse seine fleets were mainly at early morning and evening but in day-time almost all fleets creased opera-

Table 27. Frequency of "Hane" and "Seri" detected by the fishing boat in each hour of the day.

Hour	A.M. 5	6	7	8	9	10	11	12	P.M. 1	2	3	4	5	6	7	8
Hane (n_1)	5	9	18	19	18	12	3	5	5	4	5	8	3	2	3	1
Seri (n_2)	6	14	11	13	4	6	2	3	4	3	4	3	5	3	4	0
Number of shoals detected by fish finder (n_3)	25	94	120	131	119	107	101	98	86	97	85	70	57	29	16	3
$n_1+n_2+n_3$	36	117	149	163	141	125	106	106	95	104	94	81	65	34	23	4
$n_1+n_2/n_1+n_2+n_3$ (%)	30.6	19.7	19.5	10.6	15.6	14.4	7.4	7.5	9.5	6.7	9.6	13.0	12.3	14.7	30.4	25.0

tions. But since the fish finder has come into use the searching of fish at day-time has become as easy as that at morning and evening.

Furthermore, the fish finder is utilizable for indicating the swimming-water-depth of shoals and the determination of the swimming-water-depth makes the operation of purse seines very easy. Fig. 19, which is also reprinted from the author's report[42], shows the average of the top level of anchovy swimming-water-depth recording by the fish finder in the terms from morning to evening.

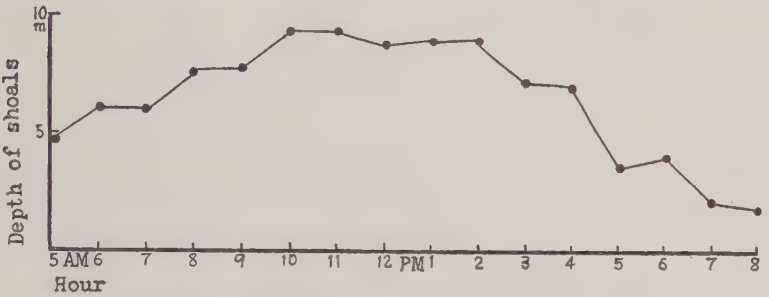


Fig. 19. Depth of anchovy shoals in each hour of the day measured from the image in a Brown style fish finder.

From this figure it is clear that anchovy swimming-water-depth at morning and evening is not so deep, about 5 metres, and at day time it is deeper than the former about 10 metres. According to this result, it may be also understood why shoals were seldom located at day-time by the indication of "Seri" and "Hane".

Raising of the fishing power by the use of fish finder

In this study, it was determined by means of dynamic resources that the fishing power of the purse seine fleets by the use of fish finders has been raised many times.

The data used are the daily and monthly catch, which were collecting from the fisheries cooperative accosiations at Ōhara, Katagai and Toyoumi in Chiba Prefecture.

At first, applying the method of measurement of the fishing power (4) the decreasing-rate of anchovy stock per month (ϕ) was calculated with the data of the monthly catch per fleet and day.

Let the natural mortality of anchovy per month is ϕ_0 the fishing-rate per month is indicated with $\phi-\phi_0$. Here, ϕ_0 is supposed as 0.02*.

The values of ϕ in each base and in each year were calculated respectively based on the monthly catch, on the Katagai fleets from Aug., 1947 to July, 1953 on the Toyoumi fleets from Aug., 1949 to July, 1953 and on the Ōhara fleets

* By Tauti[44] the natural mortality of sardine per year was estimated about 0.22. Therefore, the value of it per month may be estimated as follows: $1/12\times0.22=0.018$.

As concerning to anchovy it may be assumed equally as that of sardine or a little over ϕ_0 is supposed about 0.02, here.

Table 28. Fishing-rate per month.

Base / Period	Katagai				Toyoumi				Ōhara			
	ϕ	$\phi-\phi_0$	a	$a/\phi-\phi_0$	ϕ	$\phi-\phi_0$	a	$a/\phi-\phi_0$	ϕ	$\phi-\phi_0$	a	$a/\phi-\phi_0$
			Kan	Kan			Kan	Kan			Kan	Kan
Aug., 1952~July, 1953	0.100	0.080	1,340	16,750	0.116	0.096	1,420	14,800	0.091	0.071	1,230	17,300
Aug., 1951~July, 1952	0.113	0.093	1,300	14,000	0.067	0.047	1,080	23,000	0.030	0.010	1,070	107,000
Aug., 1950~July, 1951	0.055	0.035	1,170	33,500	0.034	0.014	880	77,000	0.030	0.010	885	85,500
Aug., 1949~July, 1950	0.043	0.023	700	30,500	0.046	0.026	640	24,600				
Aug., 1948~July, 1949	0.048	0.028	530	18,900								
Aug., 1947~July, 1948	0.043	0.023	665	28,900								

1 Kan=3.75 kg

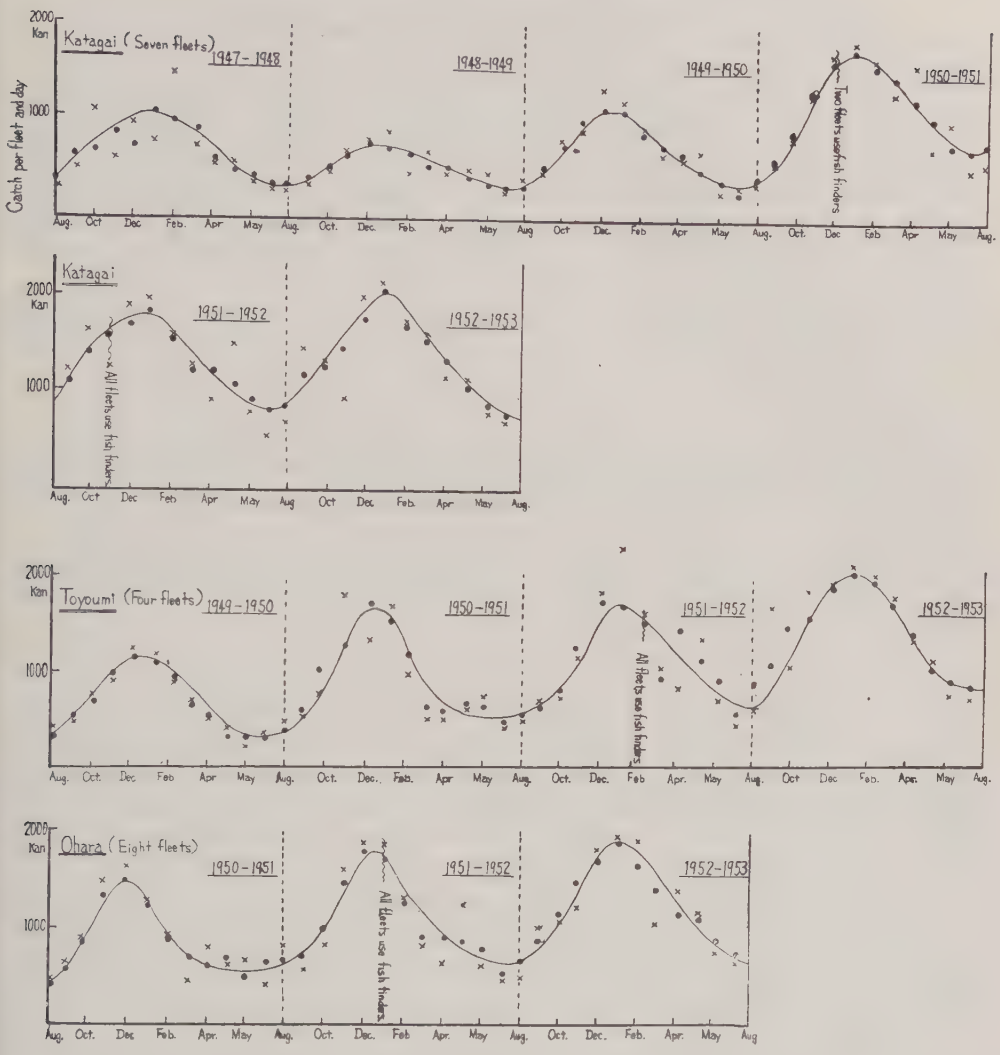


Fig. 20. Fitting of catch curve.

Note; ×: Observed catch.
●: Three month average catch.
line: Calculated value by the formula.

$$a+b\cos\left(\frac{\pi}{6}t+\varepsilon_1\right)+c\cos\left(\frac{\pi}{3}t+\varepsilon_2\right)$$

from Aug., 1950 to July, 1953 and thus the calculated values of ϕ and $\phi-\phi_0$ are shown in Table 28 and Fig. 20, respectively.

As the fish finder had began to be adapted from Nov., 1950 on someone of the fleets in each base and by Feb., 1952 it had been installed in all fleets, the efficiency of the fish finder may be expected only one year from Aug., 1952 to June, 1953. But as at Katagai five fleets among seven had fish finders until

Aug., 1951, the effect of the fish finder ought to appear in the value of ϕ in periods from Aug., 1951 to June, 1952.

By Table 28 it is clear that the fishing-rate ($\phi - \phi_0$) in each base during the period when the use of fish finders was raised as three to seven times as large when compared with those in the period when no fish finder was used. And if there is no remarkable change in the capacity of the boats, the size of nets and the fishing effort of the fleets during these periods it may be said that the fishing power of the purse seine fleets is increased three to seven times by the use of fish finders.

Furthermore, the quantity of fish coming into the fishing-ground per day is calculated by the expression:—

$$a/\phi - \phi_0 \qquad (a: \text{ the catch per day and fleet})$$

The calculated values of $a/\phi - \phi_0$ in each fishing-ground are shown in Table 28.

Following this table the quantity of arriving fish in the period from Aug., 1952 to July, 1953 in each fishing-ground was greatly decreased compared to each period prior to Aug., 1952.

Thus, it is supposed that the increase of the catch in the periods from Aug., 1952 to July, 1953 is due to the intensification of fishing operations resulting from the use of fish finders.

Comparison of the fishing power of the fleets at Katagai

The relative values of the fishing power for seven purse seine fleets at Katagai were calculated as shown in Table 29 by the method of measurement of the fishing power (1) for three periods: the first is the period when no fish finder was used, the second is when only two fleets used fish finders and the third is when every fleet used fish finders.

Following Table 29, in the period when no fish finder was used the difference of the relative values between the min. and max. was 0.70～1.37 but in the period when every fleet used fish finders it was 0.84～1.07 and this interval is less than that of the previous period.

As there is no great change in the tonnage of boats, engine power, the size of nets and the number of crew between the two periods among the Katagai fleets as shown in Tables 13 and 22, the closeness of the intervals between the min. and max. in the latter period means the balance of the fishing power among each fleet due to the use of fish finder.

In the period when only two Fleets C and D used fish finders from Jan., to May, 1951 Fleets C and D have higher relative values than the others. But the relative values of these two fleets 1.36 and 1.47, respectively are not appreciably great compared with 1.14 and 1.37, the relative values of these fleets in the period when no fish finders were used.

Such a fact may suggest that the handicap of lacking fish finders among the fleets, except Fleets C and D, had been compensated for by the increase of fishing effort, i.e. the number of days at sea and the number of operations during the period when the use of no fish finders.

Table 29. Relative values of the fishing power of the Katagai fleets.

Period	Fleet	A	B	C	D	E	F	G
The period when every fleet does not equip fish finder	Jan.~Feb., 1950	0.77	0.64	1.84	1.50	0.74	0.96	0.55
	Mar.~Apr.	1.71	0.83	0.97	1.25	0.89	0.76	0.59
	May	1.02	1.05	0.80	1.39	0.76	0.67	1.31
	June	1.43	0.60	0.99	0.64	0.84	1.00	1.50
	July	1.08	0.75	1.18	1.73	0.59	0.88	0.80
	Aug.	1.30	0.73	1.04	1.82	0.51	0.62	0.98
	Sep.	1.36	0.71	1.10	1.77	0.47	0.60	0.99
	Oct.	1.69	0.66	1.42	1.44	0.72	0.83	1.24
	Nov.	1.45	0.30	1.18	1.21	0.66	0.80	1.40
	Dec.	1.01	0.72	0.86	0.99	1.41	0.65	1.39
	Average	1.18	0.70	1.14	1.37	0.76	0.78	1.07
	δ	0.30	0.18	0.29	0.35	0.25	0.14	0.32
The period when only two fleets (C and D) equip fish finders	Jan., 1951	0.97	1.18	1.30	1.32	0.60	0.70	1.93
	Feb. ~Mar.	0.95	0.75	1.24	1.26	1.05	0.68	1.07
	Apr.	1.20	0.37	1.40	1.90	0.42	0.84	0.87
	May	1.35	0.70	1.52	1.40	0.74	0.67	0.62
	Average	1.12	0.75	1.36	1.47	0.70	0.72	0.88
	δ	0.17	0.29	0.10	0.24	0.23	0.07	0.16
The period when every fleet equip fish finder	Oct.~Nov., 1952	1.00	1.01	1.10	1.06	0.90	0.93	1.00
	Dec.	1.06	1.00	1.04	1.01	0.94	0.88	1.07
	Jan., 1953	1.08	1.19	1.14	1.22	0.72	0.86	0.79
	Feb.	1.13	1.05	1.12	1.00	1.00	0.80	0.90
	Mar.~Apr.	1.09	1.25	0.93	0.99	0.72	1.06	0.96
	Sep.	1.08	0.91	1.12	1.17	0.70	1.05	0.97
	Average	1.07	1.07	1.07	1.08	0.83	0.03	0.95
	δ	0.04	0.12	0.08	0.09	0.11	0.10	0.08

Furthermore, the effect of the fish finder is also measured by the standard deviation (δ) calculated from the relative values for the catch per day in each month as shown in Table 29. δ denotes the degree of the variance of the relative values for the catch per day.

Following this table the values of δ of each fleet in the period when every fleet use fish finder are far smaller than those in the period when every fleet does not use fish finder. This fact may be an indication that the variance of the fishing power of each fleet in each month settles down by the use of fish finders and at the same time the management of the purse seine fishery becomes easy.

§ 3. The Effect of the Wireless Telephones on the Purse Seine Fishery

The purpose of this study was to determine whether or not the use of the wireless telephone would result in increased fishing efficiency on purse seine fleets on the east coast of Chiba Prefecture.

An account of wireless telephone

The installation of the wireless telephone at first had been set up as one of the preventive measures for danger and injury of field firing of the United States army on the east coast of Chiba Prefecture (Kuzūkuri-hama).

In 1952, a land station for wireless telephone was established at Toyoumi and at the same time two fishing boats equipped with a wireless telephone were attached to Toyoumi and Katagai for the service of information on field firing to each fleet belonging to each base; in 1954 a land station was set up at Ōhara, also.

By June, 1954, all fleets at Toyoumi and Ōhara were finished with wireless telephones, and consequently anyone of the fleets were able to kept in touch closely with the others or it's land station.

Thus, the wireless telephone became very useful not only to prevent damage and injury during field firing but also to search for fish in more extensive areas compared with that period when wireless telephones had been not used.

The frequency of landing stations and wireless telephones on fishing boats is 152 MC, respectively, and the out put of the landing station at Toyoumi is 50 w/hour and at Ōhara is 25 w/hour and of the wireless telephones in each fleet, about 5–20 w/hour.

Raising of fishing power by the use of wireless telephone

For the investigation of the effect of wireless telephones on the purse seine fishery, the daily decreasing-rate of anchovy stock (f) in Katagai and the Toyoumi fishing-grounds for each year during 1950 to 1955 was calculated by the method of measurement of the fishing power (3), with the data of the catch per fleet and day. The values of f are shown in Table 30.

The daily increasing-rate of individual weight for anchovy caught (g) in the Kuzūkuri-hama fishing-ground was estimated as $1/30 \times 0.43 = 0.002$, (see, § 2). Daily fishing-rate (f_0) is expressed by the following equation as shown in the previous chapter:—

$$f_0 = f + g - e - d$$

e=daily nutural mortality

d=daily diminishing-rate by superior predator

Therefore, the daily fishing-rate of anchovy (f_0) in each year are obtained to add 0.002 (the value of g) to the value of f in Table 30 and to minus the values of e and d. But the daily nutural mortality (e) and the daily diminishing-rate by superior predator (d) are unknown factors. So, strictly speaking, the values of $f+g$ in Table 30 do not denote directly the daily fishing-rate, nor are they connected with the daily catch per fleet in (C) column.

Table 30. Daily decreasing-rate of anchovy stock and the catch per day and fleet in two bases.

Base / Year	Katagai			Ōhara			Developmental condition in the fishery
	f	$f+g$	C	f	$f+g$	C	
			Kan			Kan	
1951	0.017	0.019	1050	0.018	0.020	740	Some fleets equip fish finders
1952	0.001	0.003	1400	0.018	0.020	820	Every fleet equip fish finder
1953	0.029	0.031	1720	0.012	0.014	1050	Preparatory stage for communication with wireless telephone
1954	0.030	0.032	1680	0.037	0.039	1800	Every fleet equip wireless telephone
1955	0.029	0.031	1930	0.036	0.038	2060	

Note; f: Daily decreasing-rate of anchovy stock.
g: Daily increasing-rate of individual weight for anchovy.
C: Catch per day and fleet.

In general, the values of e and d of anchovy are such a small quantity that they may be neglected. Following Table 30, the value of $f+g$ was raised from 0.011 (the average during 1951 to 1952, the period when the use of wireless telephone) to 0.032 (the average during 1954 to 1955, the period when the use of wireless telephone) namely, 1.9 times as large compared with the previous period. And likewise, on the Ōhara fleets the value of $f+g$ was raised from 0.020 to 0.039, namely, 2.9 times as large compared with the previous period similar to the Katagai fleets.

On the other hand, the daily catch per fleet was raised from 1225 Kan (the average during 1951 to 1952) to 1805 Kan (the average during 1954 to 1955), namely, 1.5 times as large compared with the previous period on the Katagai fleets, and in the same way, on the Ohara fleets it was raised from 780 Kan to 1930 Kan, namely, 2.5 times as large compared with the previous period.

It is clear that during the period from 1951 to 1955 there is no considerable change in the tonnage of boats, the horse power of engines, the size of nets

and the number of crew, etc. on both the Katagai and Ōhara fleets. Thus, the remarkable increase of the values of $f+g$ and C during 1951 to 1955 and close correspondence between the increasing-rate of $f+g$ and C in the period of 1951 to 1952 to those in the period of 1954 to 1955 in both bases may show the powerful development of the purse seine fishery due to the use of wireless telephones.

Consequently, it may be said from these results that the use of wireless telephones on the purse seine fishery increased the fishing power of the purse seine fleets to about twice the fishing power in the period prior to the use of wireless telephone.

Comparison of the fishing power among each fleet at Katagai

In the previous study it had been known that the use of fish finders made it possible to keep a balance of the fishing power in each fleet.

In this study it was determined whether or not the difference of the fishing power in each fleet might be further closed by the use of wireless telephones.

The min. and max. in the relative values of the catch among each fleet at Katagai during 1950 to 1952 (the period when the use of wireless telephone) and during Nov. 1954 to Jan. 1955 (the period when the use of wireless telephone) were tabulated from Table 29 as shown in Table 31. According to this table, in the period when both fish finders and wireless telephones had been not used, the intervals between the min. and max. of the relative values of the catch per day was considerable large through a year. In the period when fish finders were used the intervals between the min. and max. become smaller than that in the previous period. But since that time it was shortened no further in spite of using of wireless telephones.

Table 31. Interval between the Min. and the Max. of the relative values for the catch per day.

Period of investigation	Interval between the min. and max. of the relative value of the catch per day	Developmental condition in the fishery
Jan.~Dec., 1950	0.70~1.37	Fish finder and wireless telephone are not used
Nov., 1952~Sep., 1953	0.83~1.07	Fish finder is used
Nov., 1954~Jan., 1955	0.93~1.12	Fish finder and wireless telephone are used

Nevertheless, we should never doubt the effect of wireless telephones from this fact, because such small intervals existed between the min. and the max. such as 0. 93~1.13 in the period when the use of wireless telephones must be a inevitable difference attributing to the difference of capacity of boats and nets and of technique of crew and more fortuitous accidents on boats, nets, and crew.

§ 4. The Comparison of the Fishing Power of the Purse Seine and Beach Seine

Although the beach seine at Kuzyūkuri-hama on the east coast of Chiba Prefecture had been famous as a sardines fishery from ancient times, the catch in recent years have been remarkable decreased.

In this study, the comparison of the fishing power between the purse seines and the beach seines operating in the Kuzyūkuri fishing-ground was per formed and in addition the cause of the decreasing of the catch of the beach seines was investigated.

Construction and operation of beach seine

Construction: The gear consists of a pocket net or cod end, wing net, sinker and buoy. The wing net is 150~200 m in length. The rope is usually of Manila rope and is about 1500 m length.

Operation: To surround the fish shoal, two boats are used. After the net has surrounded the fish shoal, fishermen on the beach regularly drag the rope and the wings of the net. As the net approaches the beach, the fish are driven into the pocket and are hauled up on shore.

Table 32 shows the length of nets, ropes and the number of fishermen on the beach seines in each fishing base at Kuzyūkuri-hama.

Table 32. Size of net, length of rope and number of fishermen of beach seines at Kuzyūkuri-hama.

Area / Base	A Toyoumi	B Ryokukai Hasunuma	C Sōsa-gun
Length of net (m)	250~ 300	300~350	280~300
Length of rope (m)	700~1200	1200~1500	800~1200
Number of fishermen	60~90	70~80	60~70

Comparison with the catch of beach seines in each fishing-ground

Kuzyūkuri-hama stretches over both the coast of Sanbu-gun and Kyosa-gun and along these coasts purse seines and beach seines exist together, as shown in Fig. 21. And Sanbu-gun is divided into two areas in this figure such as Areas A and B. Therefore, Kuzūkuri-hama will be sectioned for convenience three areas as follows:

Area A: Consists of Sirasato, Toyoumi and Katagai.
(The co-existance area of beach seines and purse seines)

Area B: Consists of Naruhama, Ryokukai, Hasunuma and Kamisakae.
(The particular area of beach seines)

Area C: Kyosa-Gun
(The co-existance area of beach seines and purse seines)

Fig. 21. Fishing-ground of beach seine and purse seine (1955).

Note; △: Fishing place of each beach seine
■: Loading place of each fleet of purse seine
Position of each haul of purse seine with the following catch,
●: Sardine
○: Sardine and horse-mackerel } May-Oct.
×: Sardine
⊗: Sardine and horse-mackerel } Dec.-Apr.

The unit catch of horse-mackerel and anchovy in these areas for each year during 1952 to 1954 are shown in Fig. 22. The data of statistics of catches were supplied by beach seine fishery cooperative associations in each area. In 1952 when the data of the number of days at sea of boats was not collected, the statistics of catches in this year was shown by the catch per boat and month, but in 1953 and 1954 it was shown by the catch per boat and day.

Following Fig. 22 it is clear that the highest catch appeares in Area B through three years, while the lowest catch appeares in Area C through three years.

This may be mainly due to the following reason, that is, there is only

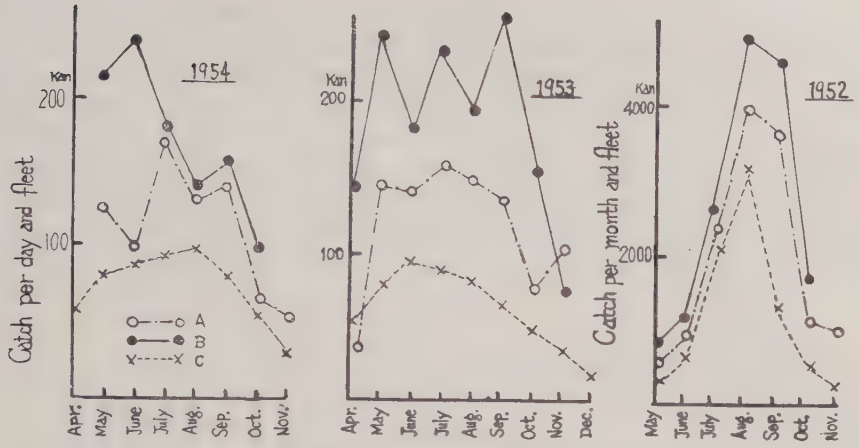


Fig. 22. Catch of beach seine in each area.
Note; 1 Kan=3.75 kg.

one purse seine fleet in Area B as shown Fig. 21 and the beach seines in Area B are larger in length of nets and ropes than those in Areas A and C, and the number of fishermen is much more than the others, too as shown Table 32, and in addition the operation of beach seines in this area is never interrupted by purse seine fleets to the contrary Areas A and C, because this area is the particular area of beach seines.

Fishing power of the beach seine

The chief species of fish caught by the beach seine are horse-mackerel and anchovy, and the fishing-season of these species seems to be regularly, fixed, that is, horse-mackerel appears mainly in the period during April to August and anchovy appears mainly in the period during September to November. In late years the catch of horse-mackerel has been continuous increasing, that of anchovy declining (Table 33).

Table 33. Yearly catch per boat at Ryokukai, Chiba Prefecture.

Species of fish / Year	Sardine		Horse-mackerel		Others		Total	
	Kan		Kan		Kan		Kan	
1950	7,750	(42)	10,000	(55)	550	(3)	18,300	(100)
1951	12,500	(36)	21,600	(62)	700	(2)	34,800	(100)
1952	8,260	(34)	15,680	(64)	460	(2)	24,360	(100)
1953	4,340	(26)	11,860	(63)	250	(1)	16,450	(100)
1954	2,400	(11)	11,160	(86)	460	(3)	13,560	(100)
1955	2,140	(17)	10,510	(81)	300	(2)	12,700	(100)

Note; Others: Mackerel and Saury-pike
( ): Per centage of catch

The daily decreasing-rate of anchovy and horse-mackerel stock (f) by the beach seine for each base was calculated by the method of measurement of the fishing power (3) and the calculated values are shown in Table 34. As the daily increasing-rate of individual weight for anchovy (g) has been estimated 0.002 in the previous paragraph and for horse-mackerel it may be supposed as 0.004.*1) According to Table 33, in the years before 1953 the catch of horse-mackerel is about 60% of the total catch, while after 1954 it is over 80%. Therefore, the daily increasing-rate of mixed individual weight of two species of fish, horse-mackerel and anchovy, is estimated 0.003*2) in the years before 1953 and after 1954 it is estimated 0.004.*3)

Table 34. Daily decreasing-rate of anchovy and horse-mackerel stock.

Year	Toyoumi	Ryokukai Hasunuma
1952	0.009	—
1953	0.017	0.012
1954	−0.001	0.003
1955	−0.004	—

Thus, the values of $f+g$*4) at Toyoumi is estimated $0.016\left(\frac{0.009+0.017}{2}+0.003=0.016\right)$ in the years before 1953 and $0.002\left(\frac{-0.001-0.004}{2}+0.004=0.0015=0.002\right)$ in the years after 1954, while at Hasunuma and Ryokukai it is estimated 0.015 (0.012+0.003=0.015) in 1953 and 0.007 (0.003+0.004=0.007) in 1954, respectively. If the daily natural mortality (e) and the daily diminishing-rate by superior predator (d) for horse-mackerel and anchovy are negliable, it might has been recognized that the fishing power of the beach seine at Kuzyūkurihama has been remarkably decreased since 1954.

On the other hand, the values of $f+g$ for anchovy on the purse seine fleets at Katagai in 1953 and 1954 had been already estimated as 0.031 and 0.032, respectively, as shown in Table 30 and these values are fifteen times as large as those of the beach seines at Toyoumi in the same year and about quintuple as large as that of the beach seines at Hasunuma and Ryokukai. The catch per day of the beach seines are 120 Kan and 180 Kan, respectively, in 1954 at Toyoumi and Hasunuma, Ryokukai, while the average catch per day of the

*1) As the research on the growing of horse-mackerel in the Eastern Pacific Ocean has not been made yet, the daily increasing-rate of individual weight for horse-mackerel is supposed about twice as large as that of anchovy from the point of view of the comparison with body-length of anchovy.

*2) $0.002\times60\%+0.004\times40\%=0.0028\fallingdotseq0.003$

*3) $0.002\times20\%+0.004\times80\%=0.0036\fallingdotseq0.004$

*4) $f_0=f+g-d-e$ (See, VI, § 4)

purse seine fleets during 1953 to 1954 at Katagai is 1800 Kan as shown Table 30.

Therefore, from above two points of view it may be supposed that the ratio of the fishing power of the beach seine to the purse seine is approximately 1:15 at Toyoumi (Area A) and approximately 1:5-10 at Hasunuma, Ryokukai (Area B).

Finally, the cause of the decrease of the catch of the beach seine in recent years was examined as follows. Following Table 35, a great deal of horse-mackerel which has been one of main species of fish caught by beach seine have been caught by the purse seine fleets year to year from 1951 (from this year fish finders have been in use).

Table 35. Yearly catch of horse-mackerel per fleet at Katagai.

Year	1948	1949	1950	1951	1952	1953	1954	1955
Catch of Horse-mackerel	Kan 210	910	1,820	13,020	6,480	10.090	15,200	17,160

And as shown in Fig. 21 the purse seine fleets are often operating from May to November close to the shore, which is the fishing-ground of the beach seine. In addition, the fishing power of the purse seine fleets have been remarkably raised in recent years by the use of fish finders and wireless telephones as described in the previous paragraphes.

Therefore, recently horse-mackerel and anchovy have been caught in abundance by purse seine fleets before they arrive at the fishing-ground of the beach seines, or these shoals are broken up into small groups by the operation of purse seine fleets.

Thus, the major cause of the decrease of the catch of the beach seines at Kuzyūkuri-hama in recent years may be attribute to the increase in the fishing power of the purse seine fleets in this same region.

§ 5. The Comparison of the Fishing Power of the Purse Seine Fleets Belonging to Different Bases

When two groups of the purse seine fleets belonging to different bases are operating in the same fishing-ground with each other, and there is no marked difference in the tonnage of boats and the size of nets between them, it may be supposed that there will be little difference in the fishing power.

If the bases to which two groups of fleets are belonging are not the same state on the harbour facilities, there may be a difference of the fishing power between two groups of the fleets even if they are in the same condition on boats and nets.

In this study, the comparison of the fishing power between the Ōhara fleets and the Katagai fleets or the Chōshi fleets and the Togawa fleets in Chiba Prefecture (two bases of each pair are different condition on the harbour facilities, respectively), was made.

I. Comparison of the fishing power between the Ōhara fleets and the Katagai fleets

Ōhara and Katagai are famous as the bases for the sardine purse seine fishery, they are mutually different in that while the former is favoured by the facilities of fishing harbour, the latter is not so because of the shallowness of the adjacent water for a great distance off shore.

This study investigated the difference in the fishery which has arisen certainly from the presence or absence of a fishing harbour.

Data

The data of the catch were supplied by the fishery cooperative associations at Ōhara and Katagai.

The time of investigation is divided into two periods, the former period is from Nov. 1952 till Apr. 1953, when the Ōhara fishing-harbour had being constructed, the latter period is from Jan. 1955 till May 1957, when the Ōhara harbour had been already constructed.

Table 36. Tonnage of seiners and size of nets.

I. Ōhara

Period of investigation	Fleet	A	B	C	D	E	F	G	H	I
Nov. 1952~ May, 1953	Tonnage (ton)	25.5	25.4	25.4	19.9	26.5	23.5	15.5	25.5	27.1
	Horse power (HP)	70	70	70	70	80	65	60	90	80
	Length of float line (m)	200	187	195	192	180	192	195	200	195
Jan., 1955~ June, 1957	Tonnage (ton)	25.5	25.4	26.4	26.0	29.7	29.7		27.0	
	Horse power (HP)	70	70	80	80	100	140		65	
	Length of float line (m)	262	256	250	250	250	250		250	

II. Katagai

Period of investigation	Fleet	J	K	L	M	N	O	P
Nov., 1952~ May, 1953	Tonnage (ton)	19.7	19.7	19.7	19.6	19.2	18.0	19.5
	Horse power (HP)	50	45	50	55	50	40	50
	Length of float line (m)	200	195	197	192	192	200	200
Jan., 1955~ June, 1957	Tonnage (ton)	19.7	19.7	19.7	19.6	19.2	—	19.5
	Horse power (HP)	65	65	55	65	60	—	60
	Length of float line (m)	225	225	200	250	210	—	225

The tonnage of the boats and the size of the nets obtained by hearing-investigations from fishermen are shown in Table 36.

Following this table the tonnage of boats of the Ōhara fleets was more or less greater than that of the Katagai fleets through the whole periods and this difference may be due to the hardship of pulling up of the boats onto the seashore and of pulling down of the boats into the sea at Katagai because of the absence of a fishing harbour.

The position of fishing bases is shown in Fig. 23.

Fig. 23. Position of fishing bases in Chiba Prefecture.

Comparison of the number of days at sea of the two groups of the fleets

The number of days at sea for each month of the Katagai fleets and the Ōhara fleets are shown in Table 37, respectively. We counted the day when only one fleet went out fishing even if without catches as the days at sea of each group of the fleets.

Table 37. Number of days at sea of the Katagai and the Ōhara fleets.

Base	1952 Nov.	Dec.	1953 Jan.	Feb.	Mar.	Apr.	1955 Jan.	Feb.	Mar.	Apr.	May	Nov.	Dec.
Katagai	10	22	13	10	6	11	14	9	11	13	17	15	20
Ōhara	9	24	13	12	8	12	18	14	16	15	16	12	23

Base	1956 Jan.	Feb.	Apr.	May	Nov.	Dec.	1957 Jan.	Feb.	Mar.	Apr.	May	Average
Katagai	9	2	9	9	11	20	14	6	13	12	3	11.6
Ōhara	11	6	15	16	14	29	18	8	19	14	7	14.5

According to this table, it is clear that the Ōhara fleets went out fishing from the harbour more frequent, about 3 days on the average, than the Katagi fleets in almost every month.

Generally, the absence from fishing of boats may arise from the following three reasons; the first is the accident of boats, fishing gears or crew, the second is the bad weather and fishing conditions, and the third is the annual functions of fishermen. But the accident of boat, fishing gears and crew seldom occurs in each fleet at the same time and the the distance between Ōhara and Katagai is not so far off that the weather and fishing conditions may be an in-

fluence at the same time on two groups of the fleets, and the absence from the fishing of boats by the annual functions is limited to few days in a year. Therefore, it may be supposed that the difference of the number of days at sea between the Ōhara fleets and the Katagai fleets has been certainly arisen from the presence or absence of fishing harbour. At Katagai on days when the wind from the sea is strong the waves break on the shore directly and the pulling up and down of the boats is very difficult because of the lack of a breakwater.

While, as there is a fishing harbour at Ōhara the fleets are not so much influenced by the wind or the waves on the incoming and outgoing of boats.

Comparison of the catch between the two groups of the fleets

Comparing the catch between the Ōhara and Katagai fleets the following two points of view were investigated; the influence of the presence or absence of a fishing harbour and the difference of the fishing power between the two groups of the fleets.

The fishing power of the two groups of the fleet was compared on the relative values of the catch per day, of the catch per pursing, and of the number of pursings.

The relative values of the three items mentioned above in the former period of investigation are shown in Tables 38 and 39, respectively, and the relative values of the catch in the latter period are shown in Table 40. In this case the relative values of the three items are calculated by the method of measurement of the fishing power (1) on the data of two groups of the fleets in a lump, as the Ōhara and Katagai fleets have been always operating in the almost same fishing-ground.

According to Tables 38 and 39, in the former period the difference of these relative values of the two groups of the fleets is small and by t-test, too it is found that these differences are not significant. Of cause there is little difference of the catch per day between both as shown in Table 41. In this case, in spite of the fleet G in the Ōhara fleets was excepted from the group of the Ōhara fleets because of small tonnage of her, the results obtained were the same.

However, in the later period, there is an obvious difference in the relative values of the catch per day and of the catch per pursing between the Ōhara and the Katagai fleets. The difference of these relative values in Table 40 were examined by t-test and they were both significant. Furthermore, for the catch per day, the Ōhara fleet are 1.5 times as large as the Katagai fleets, and for the catch per month, too, the Ōhara fleets are twice as large as the Katagai fleets (Table 42).

The cause of the difference of the results obtained in the former period and in the latter period may be considered as follows; the Ōhara fleets have been increased in the tonnage of boats and the horsepower of engines during the end of the former period to the beginning of the latter period, but the Katagai fleets have been maintained at the status quo during the same period by the reason that if the boats were larger than the usual tonnage the pulling up and down of the boats would had become more inconvenient.

The size of the nets on the Katagai fleets in the latter period become a

Table 38. Relative values of the catch per day from Nov., 1952 to Apr., 1953.

Period of investigation	The Ōhara fleets									The Katagai fleets							Mean of relative value		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Ōhara	Katagai	Ōhara (except G)
Nov., 1952	1.06	0.42	1.05	0.60	0.85	1.28	—	1.50	1.73	1.32	0.83	0.98	1.14	0.78	0.75	0.71	1.07	0.93	1.07
Dec.	1.19	0.94	1.02	0.64	0.83	0.84	0.50	1.14	0.90	1.30	1.16	1.19	1.09	1.09	0.99	1.18	0.88	1.12	0.94
Jan., 1953	1.92	0.66	0.91	0.88	0.90	1.00	0.50	1.30	0.95	1.08	1.10	1.14	1.15	0.87	0.84	0.80	1.00	1.00	1.06
Feb.	1.00	—	1.00	0.92	1.46	—	0.35	1.38	1.07	1.10	1.08	1.06	0.96	0.97	0.80	0.62	1.02	0.98	1.14
Mar.	1.16	1.09	0.90	0.70	1.09	0.66	0.57	1.48	1.42	1.33	0.98	1.02	0.76	0.96	1.26	1.07	1.01	0.99	1.06
Apr.	1.02	—	1.09	0.69	1.24	0.62	—	0.94	0.80	0.90	1.65	0.98	1.16	0.78	1.06	0.70	0.91	1.09	0.91

Table 39. Relative values of the catch per pursing and the number of pursing from Nov., 1952 to Apr., 1953.

Fleet	Meat of relative value					
	Catch per pursing			Number of pursing		
	Ōhara	Katagai	Ōhara (except G)	Ōhara	Katagai	Ōhara (except G)
Nov., 1952	1.00	1.00	1.00	1.06	0.94	1.06
Dec.	0.82	1.18	0.86	1.02	0.98	1.05
Jan., 1953	0.92	1.08	0.96	1.12	0.86	1.14
Feb.	0.92	1.08	0.96	1.00	1.00	1.05
Mar.	0.97	1.03	0.99	1.10	0.88	1.12
May	1.04	0.96	1.04	1.03	0.97	1.03

Table 40. Relative values of the catch per day from Jan., 1955 to June, 1957.

Fleet	Jan.~ Feb. 1955	Mar.~ May	June	Nov.	Dec.	Nov. 1956	Dec.	Jan., 1957	Feb.~ Mar.	May~ June
Ōhara	1.20	1.16	1.15	0.93	1.06	1.03	1.21	1.04	1.29	1.05
Katagai	0.76	0.81	0.82	1.08	0.93	0.97	0.79	0.96	0.71	0.95

Table 41. Catch per fleet and day from Nov., 1952 to Apr., 1953.

Fleet	Nov. 1952	Dec.	Jan. 1953	Feb.	Mar.	Apr.	Mean
Ōhara	650 Kan	1600	3220	2360	2140	1690	1940
Katagai	930 Kan	2020	2420	2700	1720	1640	1900

Note; 1 Kan=3.75 kg.

little greater compared with that in the former. This may be due to the fact that the boats produce a surplus of the loading capacity by the change to synthetic fiber nets (Nylon and Vinylon) which is lighter than that of cotton net.

It had been reported already by the author (see, VI, § 1) that the difference of the fishing power among the purse seine fleets is caused by the difference of the tonnage of boats and the size of nets among them. Therefore, in here, too, it is supposed that the difference of the relative value of the catch per day between the Ōhara and Katagai fleets is also caused by the difference of the tonnage of boats and the size of nets between them. But we have to view the number of pursing, since the more the number of pursing per day the more the catch per day in increased.

Table 42. Catches by the Ōhara and Katagai fleets from Jan., 1955 to June, 1957.

		Jan. 1955	Feb.	Mar.	May	June	Nov.	Dec.
Catch per fleet and month	Ōhara	94.2 (1000 Kan)	80.0	70.1	49.7	66.8	16.6	134.6
	Katagai	32.2 (1000 Kan)	24.5	27.1	30.8	44.0	17.0	58.6
Catch per fleet and day	Ōbara	5240 Kan	4700	4360	3320	4170	1380	5870
	Katagai	2300 Kan	2720	2460	2200	2590	1139	4880

		Nov. 1956	Dec.	Jan. 1957	Feb.	Mar.	May	June	Mean
Catch per fleet and month	Ōhara	19.3 (1000 Kan)	170.0	63.2	37.8	44.1	53.7	10.4	65.0
	Katagai	12.4 (1000 Kan)	106.0	27.3	5.6	23.5	39.6	3.8	32.3
Catch per fleet and day	Ōhara	1200 Kan	7200	3520	2100	2320	3840	1490	3630
	Katagai	1250 Kan	5300	1950	940	1810	2460	1290	2300

Pulling up and down of the boats at Katagai requires about half and an hour and if computed in the number of pursing it corresponds to a little less than twice. Therefore, from the individual view of the author, the number of pursings of the Ōhara fleets ought to have been increased about once or twice as compared with the Katagai fleets, but, in fact, there is almost no difference between the two fleets on the relative value of the number of pursing as shown in Table 39 or on the number of pursing per day (the average number of pursing of the Ōhara fleets is 3.58 times and that of the Katagai fleets is 2.29 times).

In the latter period there is no data on the number of pursings, nor is there any particular facts to make the number of pursings in both the Katagai and the Ōhara fleets increase. Thus, it may be not believed that the number of pursings of the Ōhara fleets become more frequent than that of the Katagai fleets during the latter period. Therefore, it may be better to think that the difference of the relative value of the catch per day between two groups of the fleets mainly depends upon the difference of the tonnage of boats and the size of the nets.

Consequently, the result of the comparison of the catch between the Ōhara fleets and the Katagai fleets is differed by the periods of investigation. Namely, in the latter period there is a material difference in the catch, that is, the catch per day of the Ōhara fleets is 1.5 times as large as that of the Katagai fleets, it is affected by the difference of the fishing power attributing from the tonnage of boats and the size of nets and the catch per month of the Ōhara fleets is 2.0 times as large as Katagai fleets, it is attributed to the difference of the number of days at sea as shown in Table 37.

Thus, this study comes to the conclusion that by the presence or absence

of a fishing harbour the difference of the number of days at sea and the tonnage of boats and the size of nets between the Ōhara and the Katagai fleets is occurred and thus, by these facts a great difference of the catch between the two fleets may arise over long unit times such as a month or a year.

II. The Comparison of the Fishing Power between the Chōshi Fleets and the Togawa Fleets

It is clear that the tonnage of the seiners of the Chōshi fleets are larger than that of the Togawa fleets as shown in Tables 43 and 44.

This is by reason of the difficulty to contribute large fishing boat at Togawa for lack of facilities of the harbour and more now the contribution of sardine purse seine boat more than 30 tons has been prohibited by fishery low in Chiba Prefecture.

Furthermore, as in recent times the Togawa harbour is becoming shallower due to filling up by sand, most of fleets at Togawa are now using the Chōshi harbour as a temporary harbour and the landing of the catch of the Togawa fleets is taken in here.

Table 43. Elements of boat and net and average relative values of the catch per day of the Chōshi fleets.

Fleet		A	B	C	D	E	F	G	H	I	J	K	L	M	N
Tonnage of seiner (ton)		28.2	33.9	29.9	35.6	39.2	30.8	34.2	26.4	23.6	34.0	30.9	41.6	36.8	34.9
Horse power of engine (HP)		120	120	120	120	80	80	85	85	80	120	80	85	90	80
Length of float line (m)		587	—	540	570	600	510	—	525	—	630	600	720	675	645
Depth of net (m)		88	—	80	85	83	83	—	80	—	90	87	90	75	80
Number of crew		65	54	48	38	41	45	40	45	37	62	60	51	68	44
Number of fish finder		4	—	4	2	2	2	—	3	—	4	4	3	4	3
Number of auxiliary boat		2	—	2	2	2	2	—	2	—	2	2	2	2	4
Relative value	1954	1.51	0.86	1.07	0.78	1.13	0.84	1.05	1.08	0.72	0.74	1.16	1.01	1.33	0.72
	1955	0.98	0.97	1.01	0.86	0.86	0.93	1.04	1.10	1.02	0.93	1.15	1.03	1.02	—
	1956	0.91	1.03	1.08	1.06	0.93	0.85	1.04	1.04	0.90	1.04	1.05	1.01	1.09	—
	1957	0.90	0.98	1.06	—	0.93	0.99	0.91	1.08	0.97	1.08	1.08	1.05	1.00	—

Table 44. Elements of boat and net and average relative values of the catch per day of the Togawa fleets.

Fleet		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Tonnage of seiner	(ton)	24.9	25.7	29.7	26.0	28.2	23.1	22.7	26.3	26.9	18.5	23.7	18.7	22.1	27.0	16.1
Horse power of engine	(HP)	57	85	80	75	70	75	65	80	75	70	65	80	80	80	50
Length of float line	(m)	475	495	457	495	495	—	—	525	—	475	480	460	—	480	450
Depth of net	(m)	73	90	90	85	90	—	—	92	—	67	90	70	—	70	65
Number of crew		58	51	50	40	57	63	41	36	—	41	44	33	39	41	38
Number of fish finder		3	4	5	4	4	—	—	4	—	2	2	2	—	2	2
Number of auxiliary boat		2	2	3	3	3	—	—	2	—	2	2	2	—	2	2
Relative value	1954	1.16	1.38	1.22	1.16	1.40	1.05	1.08	0.59	0.68	0.49	1.07	0.79	1.23	0.70	—
	1955	1.52	1.28	1.46	1.19	1.17	1.34	1.35	0.44	0.60	0.50	1.14	0.72	0.44	1.18	0.67
	1956	1.25	1.23	1.59	1.3.	0.99	1.45	0.46	0.76	—	0.61	0.70	0.54	—	1.38	0.74
	1957	1.05	1.31	1.21	1.22	1.14	1.10	0.77	0.69	—	0.70	1.48	0.57	—	1.08	0.69

Fishing power of the Chōshi fleets and the Togawa fleets

Before comparing the fishing power between the Chōshi and the Togawa fleets the fishing power of the purse seine fleets in each harbour was measured. The catch data from 1954 to 1957 was supplied by the fishery cooperative associations of both bases and the elements of boats and nets as shown in Tables 43 and 44 were obtained by hearing-research from fishermen.

Though the relative values of the catch of each fleet in both bases were calculated for each month during 1954 to 1957 by the method of measurement of the fishing power (1), they were tabulated as the mean values through four years in Tables 43 and 44, respectively, as to avoid a complication of table.

According to Table 43 the fleets showing relative values more than 1.00 throughout the whole period of four years are Fleets C, H, K, L and M and that fleet showing more than 1.00 for three years out of the four years is Fleets G. Therefore, we conclude that these six fleets are superior among the Chōshi fleets in regard to fishing power. The inferior fleets are concluded to be Fleets A, B, E and I.

The Chōshi fleets can be divided into three classes; those below 30 tons, from 30 to 40 tons and more than 40 tons.

Generally, it is believed that the larger tonnage fleets are more efficient such as Fleet L which is 41.6 tons as shown in Table 43, however, this table also shows that Fleet E which is about 40 tons, is not as good in regard to fishing power, and Fleet C, which is less than 30 tons, is very efficient.

Consequently, the relation between the relative value of the catch and

the tonnage of the seiners is out of proportion. Thus, it is seen that the fishing power of the Chōshi fleets is not influenced so greatly by the tonnage of boats and the size of nets.

While, according to Table 44, at Togawa the fleets showing relative values more than 1.00 for the period of more than three years are Fleets A, B, C, D, E, F and N and the ones showing relative values less than 1.00 for the periods of more three years are Fleets H, I, L and O.

In conclusion, at Togawa the difference in the tonnage of seiners between superior and inferior fleets in regard to fishing power is not so great, but the difference in the relative values of the catch between the larger and the smaller tonnage fleets is very great. While, at Chōshi though there is a greater difference in the tonnage of seiners compared with that of the Togawa fleets the difference in the fishing power between the superior and the inferior fleets is not so great.

Comparison of the fishing power between the Chōshi and the Togawa fleets

Now, both the Chōshi and the Towawe fleets are starting from Chōshi harbour and operating almost on the same fishing-ground.

Therefore, we are able to compared the fishing power of the Chōshi and the Togawa fleets with the average monthly catch showed in Table 45 by the *t*-test, and the result obtained by this test is clearly significant.

Table 45. Monthly catch per day and fleet.

Fleet	1954, Feb.	Mar.	Apr.	1955 Jan.	Feb.	Mar.	Apr.	May	Nov.	Dec.	1956 Oct.	Nov.	1957 Jan.	Feb.	Mar.	Average
	Kan															
Chōshi	1680	2110	1570	1790	2100	1650	3350	2960	2180	1810	1840	3100	2760	1790	2640	2220
Togawa	1640	1880	1420	2060	3400	1350	1870	2440	280	2200	570	580	1960	1390	2690	1720

Note: 1 Kan=3.75 kg

Namely, it is recognized that a very large difference of the catch per day and fleet exists between two groups of the fleets.

This may be caused by the difference of the tonnage of seiners between two groups of the fleets as shown in Tables 43 and 44, or the difference of the technique of the crew between the two groups of the fleets.

We suppose according to the results obtained from the previous studies, [VI, § 1 and § 5 (1)] that the difference of the catch between the Chōshi and Togawa fleets is due to the tonnage of seiners and the size of nets rather thar the technique of the crew.

§ 6. The Comparison of the Fishing Power of Two Groups of the Fleets Operating in Different Fishing-Grounds

In this study, the comparison of the fishing power between two groups of the fleets operating in two different fishing-grounds, such as a pair of Tokyo Bay and Kuzyūkuri, and a pair of Ōhara and Chōshi is investigated.

I. The comparison of the fishing power between the Tokyo Bay fleets and the Kuzyūkuri fleets

Data

In Tokyo Bay, Tateyama in Chiba Prefecture and Sajima in Kanagawa Prefecture were selected as the object of investigation, (Fig. 19) and in Kuzyūkurihama, Ōhara and Katagai were selected.

According to Table 46 it is seen that the tonnage of the seiners and the length of the nets of the Kuzyūkuri fleets are larger than that of the Tokyo Bay fleets, but the depth of the nets of the former is shallower than that of the latter. This may be due to the difference of the the condition of each fishing-ground, namely, in Tokyo Bay 200 m same-depth-line closes to near the coast and the main fishing-ground is formed between 20 m and 200 m same-depth-lines as shown in Fig. 24. Naturally, the area of the fishing-ground of the former is narrower compared with that of the latter. Thus, the length of the nets of the Kuzyūkuri fleets is longer but the depth of the nets is shallower.

Table 46. Elements of boat and net in two fishing-grounds.

	The Tokyo Bay fleets	The Kuzyūkuri fleets
Tonnage of seiner (ton)	15～20	20～40
Style of seiner	Western style	Japanese style
Length of float line (m)	330～380	400～570
Depth of net (m)	60～80	40～60
Number of crew	40～50	50～60
Number of fish finder	1	3
Wireless telephone	none	exist

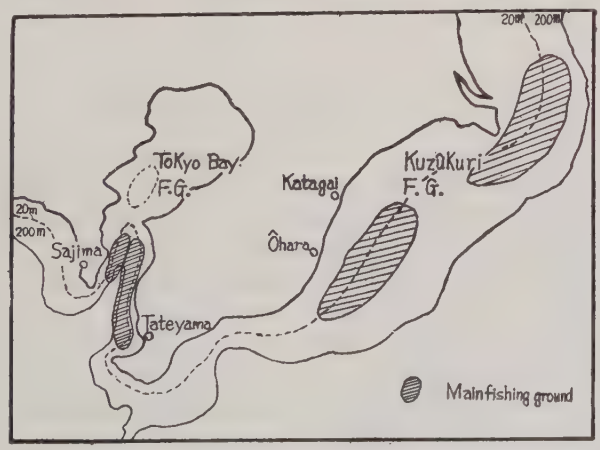


Fig. 24. Tokyo Bay fishing-ground and Kuzyūkuri fishing-ground.

The fish caught by the purse seines in Tokyo Bay are raised in the fish-preserve in Tateyama Bay as bait for the skipjack and tuna hand-line fishery, but in Kuzyūkuri-hama they are used for food and manufactured into manure.

Comparison of the number of days at sea and of pursing

The number of days at sea of the Tokyo bay fleets and the Kuzyūkuri fleets is compared in Table 47. Following this table, it is shown that the number of days at sea of the Tokyo Bay fleets is greater than that of the Kuzyūkuri fleets, this may be attributed to the difference of the weather condition, especially the wind.

Table 47. Number of days at sea of fleets in each base.

Date	The Tokyo Bay fleets		The Kuzyūkuri fleets		
	Sajima	Tateyama	Ōhara	Katagai	Chōshi
Jan. 1954	18	10	9	8	10
Feb.	13	13	9	9	10
Mar.	16	6	11	6	9
Apr.	28	14	17	13	16
May	26	22	10	15	17
June	18	17	—	8	—
July	18	15	17	17	11
Aug.	10	18	4	3	6
Sep.	17	16	—	9	—
Oct.	26	24	—	11	—
Nov.	23	18	14	12	13
Dec.	25	20	15	13	17

The number of pursings per day of the Tateyama and the Katagai fleets are shown, respectively, in Table 48 and from this table it is seen that the number of pursings per day of the Katagai fleets are numerically superior to the other. This reason may be due to the numerous shoals in the Kuzyūkuri fishing-grounds compared with the Tokyo Bay fishing-ground or the methods of finding shoals of the Kuzyūkuri fleets is better than that of the Tateyama fleets because the Kuzyūkuri fleets have three fish finders for one fleet, against the Tateyama fleets which have only one fish finder for one fleet and in addition the Kuzyūkuri fleets always keep in touch each other with wireless telephones on the fishing conditions but the Tateyama fleets do not because they lack wireless telephone.

Table 48. Number of pursing of fleets in two bases.

Fleets	1954 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
The Tateyama fleets	2.6	2.7	1.3	2.5	3.5	3.7	4.7	2.0	3.2	3.2	3.9	3.6	3.08
The Katagai fleets	3.3	3.1	2.6	3.3	3.8	4.5	4.6	4.4	3.2	3.8	4.1	2.9	3.63

Comparison of the fishing power

The fishing-power of the purse seine fleets in both fishing-ground is comcared with the decreasing-rate of the anchovy stock by the method of measurement of the fishing power (3).

The daily decreasing-rate of the anchovy stock in weight (f) in Tokyo Bay was calculated based on the data of the catch per day and fleet during 1953 to 1955; the results obtained are shown in Table 49.

The decreasing-rate of anchovy stock in Kuzyūkuri, which had been shown already, in Table 30, are tablulated again in Table 49 for convenience of the comparison of the both.

Table 49. Decreasing-rate of anchovy stock per day in weight at two fishing-grounds.

Year	The Tokyo Bay fleets				The Kuzyūkuri fleets			
	Tateyama		Sajima		Ōhara		Katagai	
	f	$f+g$	f	$f+g$	f	$f+g$	f	$f+g$
1953	0.003	0.005	—	—	0.012	0.014	0.029	0.031
1954	0.010	0.012	0.005	0.007	0.037	0.039	0.030	0.032
1955	—	—	0.008	0.010	0.036	0.038	0.029	0.031

Note; f: Decreasing-rate of stock per day in weight
g: Increasing-rate of individual weight per day

In order to calculate the increasing-rate of individual weight of anchovy (g) the size composition of anchovy caught in both fishing-ground is tabulated in Table 50, based on the fisherman's daily records on catches, in which size composition is classified into three classes judged by the eye-measurement of fisherman, such as large, intermediate and small.

Following this table, there is a great difference in the size composition between both fishing-grounds.

In Tokyo Bay a large per centage of the amount of fish caught is composed of the intermediate and small size fish, while in Kuzyūkuri over half of the amount of fish caught is the large and intermediate size fish.

Table 50. Yearly catch and their per centage for size-composition in catch fishing-grounds.

Size of fish	Tokyo Bay				Kuzyūkuri			
	S	M	G	T	S	M	G	T
1952								
Catch (1000 Kan)	583.7	1236.7	33.7	1855.9	4702.1	2300.3	3330.6	10,333.0
Per centage	31	67	2	100	45	22	33	100
1953								
Catch (1000 Kan)	495.5	1844.2	12.4	2352.1	4434.3	2220.1	4199.2	10854.1
Per centage	21	78	1	100	41	20	39	100
1954								
Catch (1000 Kan)	283.3	1277.5	209.4	1770.2	3335.8	1616.4	8975.5	13929.1
Per centage	16	72	12	100	24	12	64	100
1955								
Catch (1000 Kan)	321.4	1413.1	132.4	1867.0	5241.2	4757.5	14128.0	24126.5
Per centage	17	76	7	100	22	20	58	100

Note; S: Small size M: Intermediate size
G: Great size T: Total

Therefore, the monthly increasing-rate of individual weight of anchovy in both fishing-grounds is estimated as follows;

Tokyo Bay fishing-ground:

$$1/12\times\frac{15-7}{\frac{15+7}{2}}=0.061^{*}$$

Kuzyūkuri fishing-ground:

$$1/12\times\left(\frac{15-7}{\frac{15+7}{2}}\times 0.5+\frac{17-12}{\frac{17+12}{2}}\times 0.5\right)=0.043$$

According to this calculation, the value of the monthly increasing-rate in Tokyo Bay is a little greater than that in Kuzyūkuri.

But if computing in terms of daily increasing-rate they will come together at about 0.002.

* According to Data from Survey of Anchovy Resouces[45] small and intermediate size fish are yearling or one-year-old and body-length of them are 4–11 cm and their body weight increase from 7 to 15 g during a year. The large size fish are almost two-years-old and their body-length and body-weight are increase from 12 to 15 cm and from 12 to 17 g during a year, respectively.

As the value of f showing in Table 49 includes natural mortality (d) and diminishing-rate by superior predator (e) it is not correct to compare the fishing power between two groups of the fleets with the value of f.

But if we can ignore (d) and (e) because these values are small enough, it will be estimated that the fishing power of the Kuzyūkuri fleets is three six times as large as the Tokyo Bay fleets.

Furthermore, the catch per day and fleet of the Kuzyūkuri fleets is about three times as large as the Tokyo Bay fleets as shown in Table 51.

Table 51. Catches per day and fleet of two groups of the fleets

Year	The Tokyo Bay fleets		The Kuzyūkuri fleets	
	Tateyama	Sajima	Ōhara	Katagai
1 9 5 3	705 Kan	— Kan	1320 Kan	1720
1 9 5 4	660	675	1800	1680
1 9 5 5	—	515	2070	1930

From these points of view it may be said that the fishing power of the Kuzyūkuri fleets is, at least, about three times as large as that of the Tokyo Bay fleets.

This difference of the fishing power may be owing to such facts as the difference in tonnage of seiners and number of pursings, or the difference of the amount of shoals coming into each fishing-grounds, or the difference of the fishing-ground condition, because in Tokyo Bay the tide runs stronger and the sea is deeper than off the Kuzyūkuri fishing-ground and therefore the pursing operation is more difficult.

II. The comparison of the fishing power between the Chōshi and the Ōhara fleets

The distance between Chōshi and Ōhara is relatively far off each other as shown in Fig. 25, therefore, the Chōshi and the Ōhara fishing fleets are always operating in the different fishing-grounds.

In this study, the difference of the distribution and the dissolution of the daily catch between two groups of the fleets are examined, which might has been attributed to the discord of the fishing-grounds.

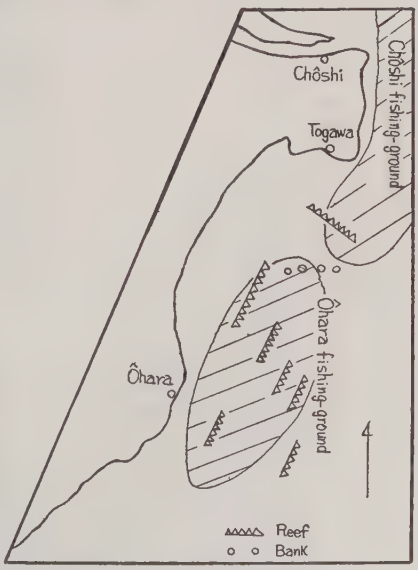


Fig. 25. Chōshi and Ōhara fishing-grounds.

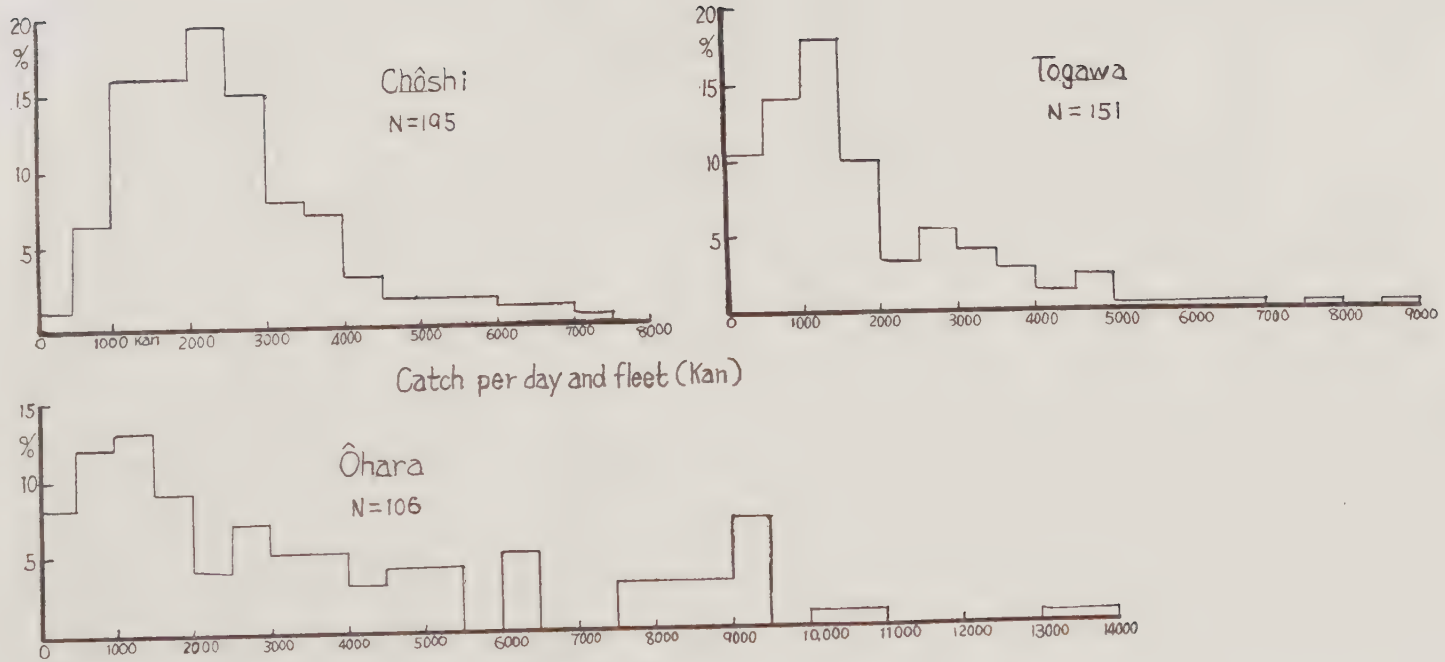


Fig. 26. Distribution of the catch of three groups of the fleets in 1955.
Note: 1 Kan=3.75 kg N: Numbers of data

The distribution of the daily catch in Chōshi, Togawa and Ōhara in 1955 are shown in Fig. 26. The degree of the dissolution of the daily catch in each base is illustrated by S/C as shown in Table 52, where S denotes the standard deviation of the daily catch and C denotes the mean daily catch. This table also shows the catch per day and fleet by three group of the fleets and by this table it is clear that the Ōhara fleets take the heighest daily catch on the average. It had been already pointed out in VI, § 5, that the cause of the difference of the daily catch between the Chōshi and Togawa fleets is due to the difference of tonnage of seiners and of size of nets.

In regard to the mean value of S/C, the Ōhara fleets show the greatest value among the three groups of the fleets, and this fact means the fluctuation of the catch day to day of the Ōhara fleets is the greatest. The Chōshi fleets show the smallest value of S/C and this also means the fluctuation of the catch of the Chōshi fleets is remarkably less than the others. Such fact may be understood, too, from the comparative illustration of the distribution of the daily

Table 52. Catch per day and fleet and their dissolution for three groups of the fleets.

Date	The Chōshi fleets		The Togawa fleets		The Ōhara fleets	
	C	S/C	C	S/C	C	S/C
	Kan		Kan		Kan	
1954 Feb.	1680	0.50	1640	0.49	1750	1.08
Mar.	2110	0.39	1880	0.84	1820	1.13
Apr.	1570	0.45	1420	0.82	2950	1.05
1955 Jan.	1790	0.68	2060	0.57	5220	0.65
Feb.	2100	0.61	3400	0.67	4710	0.86
Mar.	1650	0.53	1350	0.78	4170	0.64
Apr.	3350	0.33	1870	0.87	3300	0.60
May	2960	0.28	2440	0.94	4160	1.11
Nov.	2180	0.39	280	0.43	1390	0.88
Dec.	1810	0.34	2200	0.54	5140	0.69
1956 Oct.	1840	0.22	570	0.38	1810	0.67
Nov.	3100	0.25	580	0.80	1200	0.74
1957 Jan.	2760	0.21	1960	0.56	3520	0.94
Feb.	1790	0.33	1390	0.78	2110	0.84
Mar.	2640	0.58	2690	0.87	3400	0.60
Average	2220	0.41	1720	0.72	3100	0.83

Note: C: Catch per day and fleet
S/C: Dissolution of the daily catch

catch in Fig. 26.

The tonnage of seiners between the Chōshi and the Ōhara fleets is little differ as shown in Tables 43 and 36. If there is no difference of the technique of crew between them the difference of the distribution and the dissolution of the daily catch may be mainly due to the different conditions of the fishing-grounds.

Namely, in the Ōhara fishing-ground many banks and rocks are scattered on the bottom of the sea as shown in Fig. 25 and these reefs act as to stop the migration of shoals and to make shoals remain there for a long time, the Ōhara fleets are often favoured by chance to catch large groups of shoals; While, in the Chōshi fishing-grounds as there are no banks and rocks, large groups of shoals such as those in Ōhara fishing-ground seldom appear. Therefore, the mean daily catch of the Ōhara fleets is larger than that of others and at the same time, the distribution of the daily catch may deviate from the normal distribution.

As the Chōshi fishing-ground may be suitable to concentrate fish from environmental view points, namely, as the Kurile current and the Kuroshio mix with each other in this area and in addition the Tone river discharges itself into this sea-area, the Chōshi fishing-ground is abundant in nutritive substance for fish food.

Therefore, small and intermediate groups of shoals may appear in succession in this fishing-ground even if large groups of shoals do not appear readily. Thus, the distribution of the daily catch in the Chōshi fishing-ground may show the semi-normal type.

§ 7. The Effect of Smaller-Sized Mesh of the Purse Seine on the Capture of Anchovy

Recently, there is a common tendency in purse seine fisheries for the mesh size of the purse seine to becomes smaller and smaller. On horse-mackerel and mackerel purse seines in the East China Sea the mesh size is changing from 4.3 cm to 2.7~3.8 cm and on anchovy purse seines in Chiba Prefecture it is replaceing from 1.4~1.6 cm for 1.2~1.3 cm (streached mesh size, respectively). The smaller sized mesh will bring about an advantage to catch smaller fish which are liable to escape through ordinary size meshes, and as the result, the amount of catchwill be increase, but viewed otherwise, it will a considerable problem on the fish resources.

In this study, the effect of the reduction of the mesh size on the catching of anchovy by purse seines is investigated.

Rate of the number of gilled fish for different mesh size nets

In May, 1953, the author went abroad the Shinsei-Maru (19 tons), a seiner of the two boats purse seine fleet based on Tateyama in Chiba Prefecture, and observed the rate of the number of gilled fish for each different mesh size walls of the seine.

The principle of catching fish on purse seine is surrounding and scooping

fish but not gilling fish like as gill net. But if fish enclosed with seine are too small to retain in walls of seine or the mesh size is too large in proportion to the size of fish, any fish in the seine may be able to escape through meshes but any fish may be gilled by meshes.

Practically, we have often observed that the meshes of purse seine are jamed with fish and fishermen try to clear away them with bamboo-ladles. In this case it is seen that if mesh size of seine would had been a little greater most of the fish which were gilled in the meshes would have been able to escape through meshes.

Fortunately, just at that time, purse seines in Chiba Prefecture had being converted from cotton fiber net to synthetic fiber net and the seine of the Shinsei-Maru was, too, converted, experimentally, to synthetic fiber walls of net in some part of the seine as shown in Fig. 27.

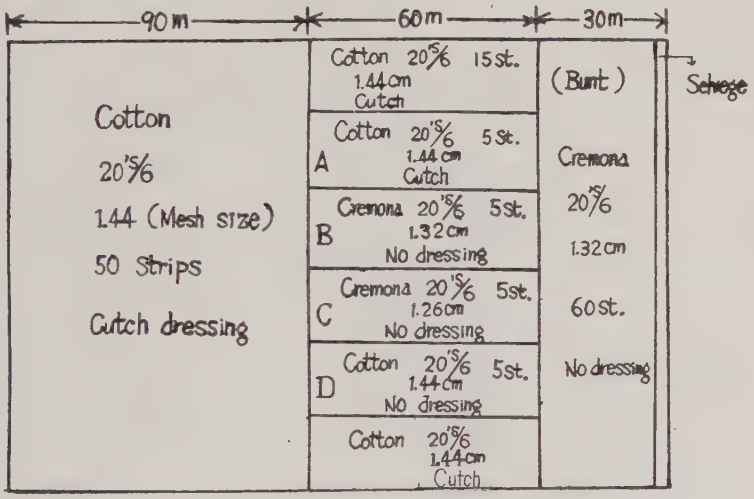


Fig. 27. Specification of the purse seine of the Sinsei-Maru.
(one half of the seine)

Following to this figure, the one half of the sine is divided into three sections; the first is a part from the selevage of bunt to 30 m to left along the float line, the second is a part from the left side of the first section to 60 m to left and the third is the remainder part. The walls of net for observation, which are consist of some different characteristic nets in material of fiber. size of mesh and colour of net, are arranged in the second section.

The observation was made as the following programs. Hauling the net begins from the wing and when it comes to the intermediate of one half of the seine, the walls of the net will be obviously recognized on the sea-surface. Then, for convenience of counting, the condition that full meshes in one wall for observation are jamed with fish is fixed as 10 and the range of the rate of the number of gilled fish is roughly fixed by eye-measurement as from 1 to 10. Such observations were carried out three times on separate days, May 7th, 10th

and 12th, 1953.

Following Fig. 27, Net B and C in the second section are Cremona (Vinylon) net (20 s/6) and their colour are white for no dressing, while Net A is cotton net (20 s/6) and dressed with cutch, light brown colour, but the apparent colour of Net A is gray owing to cutch being dissolved in the water.

Therefore, in order to examine only the influence of the size of the mesh on the number of gilled fish, the effect of material and colour of walls of the net should be compensated for in advance. But we suppose that as the difference of the material and the colour of walls of the net have no great influence on catching, judging from the process of purse seine fishing it is no need to consider about the effect of material and colour of the net. But the effect of position of walls of the net was considered, namely, same characteristic nets (Nets A and D) were arranged as a contrast up and down of Net B and C, respectively. The body-length of fish was measured on 20 gilled fish which were picked up from meshes at random for each wall of the net for observation.

The results obtained are shown in Table 53.

Table 53. Rate of the number of gilled fish for different mesh size of nets.

Date of observation	Catch (Kan)	Species of fish	Size of fish (cm)	Rate of the number of gilled fish			
				Net A (Mesh size) (1.44cm)	Net B (1.32 cm)	Net C (1.26 cm)	Net D (1.44 cm)
May 7	1500	anchovy	6.0~6.5	4	1	0	3
10	800	〃	5.0~6.0	3	2	1	3
12	1200	〃	8.0~8.5	0	0	0	0

1 Kan=3.75 kg

This table showst hat there is little difference in the number of gilled fish with meshes between Net A and D, so that, the effect of the position of walls of the net may be negliable. Furthermore, according to this table it is found that there is no difference of gilling between the fish of 5.0~6.0 cm in length and the fish of 6.0~6.5 cm and the fish of 8.0~8.5 cm in length never gill with each mesh.

In Net C of 1.26 cm mesh size few fish of 5.0~6.0 cm in length gill but those of over 6.0 cm in length never gill. Both Net A and D of 1.44 cm mesh size show more increased rate of the number of gilled fish on the fish of 6.0~6.5 cm and 5.0~6.0 cm in length compared with Net B and C.

In the same way, in Net B of 1.32 cm mesh size few fish of over 6.0 cm in length gill and of course the fish of 5.0~6.0 cm in length much gill, than in Net C.

As a conclusion of this observation, it is seen if the mesh size varies a little, for example, even 0.6~0.8 cm, the number of gilled fish would be changed. Viewing this result, the shortening of the mesh size on the purse seine, even

if it were less 1.0 cm, will bring a considerable effect on the catch of smaller size fish.

Length distribution of anchovy caught for different mesh size

The relation between the body length distribution of anchovy caught and the mesh size of the purse seine was examined based on the data from Survey of Iwasi (Sardines) Resources.

The data in this survey was collected from 21 purse seine fleets based at Chōshi, Chiba Prefecture, in the periods 1954–1957 and 22 purse seine fleets based on Isohama, Ibaragi Prefecture, in the periods of 1954–1955.

The mesh size of the whole seines at Chōshi was holding 1.60 cm through the periods of 1954–1955, and that at Isohama was holding 1.32 cm through the same periods. Therefore, on the mesh seine at Chōshi and Isohama, there was a difference of 0.28 cm.

The distance of the two fishing bases is a little far off as shown in Fig. 28. The fishing-grounds of the fleets of the both bases are not in common, but sometimes the Chōshi fleets went out to the Isohama fishing-grounds.

Fig. 29 shows the length distribution of anchovy caught in both fishing-grounds. By this figure, it is clear that the range of the length distribution of anchovy caught at Isohama is wider than at Chōshi in the periods of 1954–1955 and the fish of 5.0～7.0 cm in body-length have hardly been caught in the Chōshi fishing-ground throughout the whole period of the investigation.

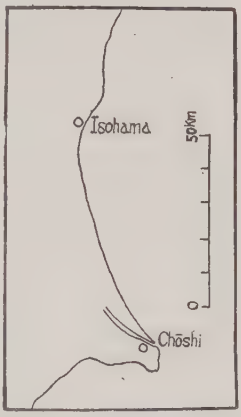


Fig. 28. Bases of purse seine fleets.

The reason for this difference may be attributed to the following two assumptions.

1) The difference of the body-length composition of anchovy coming to both fishing-grounds. In the Isohama fishing-ground smaller size fish appear frequently.
2) If the body-length composition of anchovy coming to both fishing-grounds were the same, in the Chōshi fishing-ground the smaller size fish would have been able to pass through the 1.60 cm meshes (the mesh size of the purse seine at Chōshi in 1954–1955) or gilled in the meshes.

By hearing-research from fishermen it is supposed that there is no great difference in the body-length of anchovy coming to both fishing-grounds. And this supposition may be not greatly in error judging from the fact that the distance of both bases is not far.

If this supposition is true, the difference in the range of the length distribution of anchovy caught between Chōshi and Isohama in 1954–1955 may depend upon the selectivity of mesh such as the assumption mentioned in 2). And the existence of the selectivity of mesh on the purse seine has been already

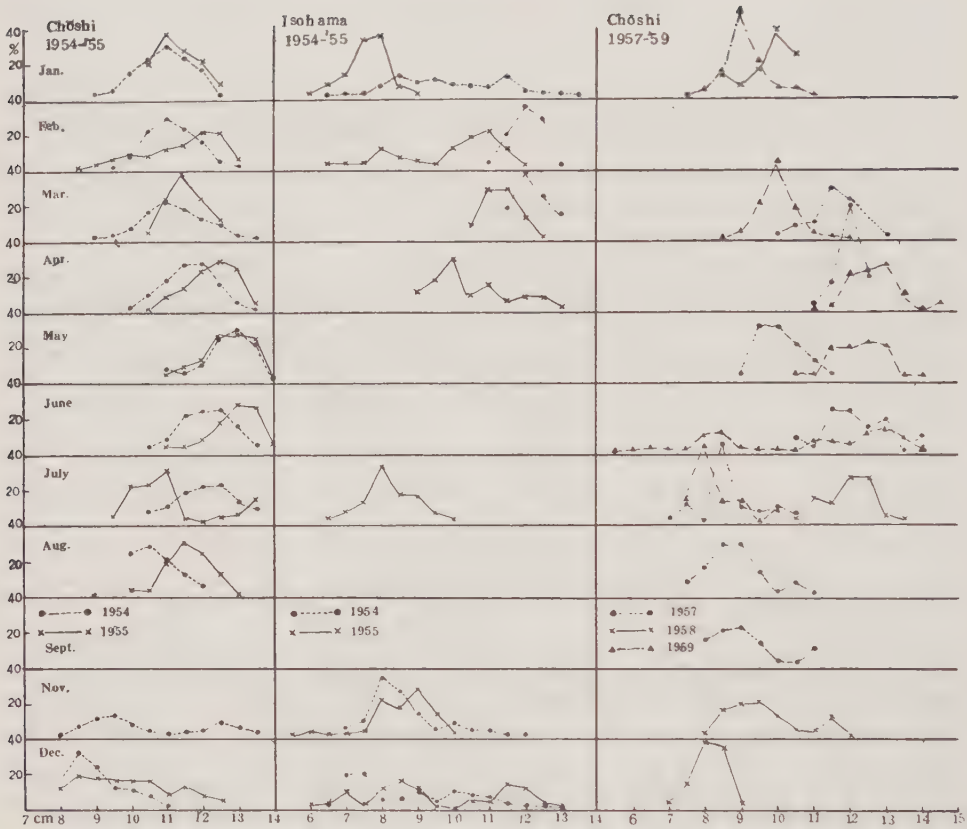


Fig. 29. Length distribution of anchovy caught in Chōshi and Isohama.

recognized by the result of the observation made on the Shinsei-Maru.

Thus, in view of the results so far achieved, it is estimated that the fish of 5.0~7.0 cm in length, which have not been shown in the illustration of length distribution of anchovy caught in the Chōshi fishing-ground (Fig. 29), have escaped through meshes of 1.60 cm of the Chōshi purse seines or gilled in the meshes, while in the Isohama fishing-ground they have been caught without escaping and gilling by smaller mesh size of 1.32 cm.

By the fishermen at Chōshi, it is said that the reason for using the seine with larger mesh size compared with the Isohama purse seine is because they catch mainly sardine (*Sardinops melanosticta*) body-length of which is larger than anchovy. But in recent years, as the production of anchovy by purse seines in these fishing-grounds have amounted to over 90 per cent of the yearly catch, the purse seines at Choshi are being converted to ones with smaller size mesh as 1.20~1.40 cm for the capture of anchovy since 1956. Until 1958 the entire fleets at Chōshi had changed to the seines with 1.60 cm mesh size as like as Isohama purse seines. Thus, in the comparison of the length distribution of anchovy caught at the Chōshi fishing-ground between the periods of 1954-1955

and the periods of 1957–1959 (Fig. 29) it seems that the range of the length distribution in the latter period is wider than that in the former periods, but the degree of its difference is less than that between Chōshi and Isohama in the periods of 1954–1955. In order to describe more simply and obviously these relationship, Fig. 29 is summarily tabulated as shown in Table 54.

Consequently, it may said that the shorting of mesh size of purse seine will bring about an efficient effect on the catching of smaller size fish and accordingly, the total amount of landing will be increased, however, it may be also bring about a harmful influence of the fish resources.

Table 54. Relation between mesh size and body-length of anchovy caught.

Body-length	Chōshi 1954～1955 (Mesh size) 1.60 cm	Isohama 1954～1958 1.32 cm	Chōshi 1957～1958 1.32 cm
Body-length on average (cm)	11.3	8.2	9.6
Range of body-length between Min. and Max. (cm)	7.0～13.5	5.5～13.5	5.5～15.0

VII. The Fishing Power of the Purse Seine Fleets for Sardine, Mackerel and Horse-mackerel

Nagasaki and Chiba Prefectures have been famous as the centre of the purse seine fisheries in Japan, but there is some differences in the fishing system between the regions; the seine fleets based in Chiba Prefecture are mostly 10～40 tons class and catch mainly anchovy in the closed sea of its own prefecture in day time, while, the seine fleets based in Nagasaki Prefecture are 40～80 tons class and catch not only sardines but also mackerel and horse-mackerel in the vast areas of the East China Sea in night-time with the aid of fish luring lamps. In addition, usually, the former fishery is operated by two boats purse seines and the latter is operated by one boat purse seines.

The number of seine fleets operating in the East China Sea is about 300 in total and the fleets in Nagasaki Prefecture amount half of them.

In this chapter, at first, the fishing power of the purse seine fleets in Nagasaki Prefecture have been investigated, secondly, the fishing power between the purse seine fleets based in Nagasaki Prefecture and the ones based in the other five prefectures facing the East China Sea have been compared and the third, the fishing power between the coastal (small) purse seine fleets and the lampara net fleets, both of which are operating along the coast of Nagasaki Prefecture, have compared.

§ 1. The Fishing Power of the Purse Seine Fleets in Nagasaki Prefecture

Hitherto, the purse seine fisheries in the western sea of Japan had been

carried out by two kinds of fishing types; the one is one boat purse seine for sardine in the sea of surrounding Goto and Amakusa, and the other is two boats purse seine for mackerel and horse-mackerel in the offing of Yamaguchi, Shimane, Tottori Prefecteres and in the sea of surrounding Tsushima.

But, as the catch of sardine in the sea surrounding Gotō and Amakusa had decreased extremely since the period of 1952, one boat purse seine fleets operated in these areas had gone out to search for better fishing-grounds toward Yamaguchi, Shimane, Tottori Prefectures and at present they have been operating to catch horse-mackerel and mackerel, in stead of sardine, in these areas together with two boats purse seine fleets which have been operating exclusively in these areas.

Unfortunately, such a confusion of the fisheries has brought about a fishing antogonism in these areas between one boat purse seine fleets and two boats purse seine fleets or other coastal fishing boats such as gill net and lift net boats.

On the other hand, with the removing of the fishing-ground from shore to offing, the one boat purse seine fleets have been modified to large tonnage and more the nets of them have been converted to catch mainly mackerel and horse-mackerel rather than sardine.

In this study, to provide the fundemental data for the management of the fisheries in the East China Sea the fishing power of each one boat purse seine fleets based on various places in Nagasaki Prefecture was investigated and also the comparison of fishing power between one boat purse seine fleets and two boats seine fleets was made.

Data

The data used in this study are of 158 fleets in Nagasaki Prefecture, monthly catches for four species of fish, sardine, round-herring, horse-mackerel and mackerel, in the period from Sep., 1956 to Aug., 1957 and they are supplied from Nagasaki Branch of the Statistics and Survey Division.

Another species of fish caught are anchovy, squid, bream, frigate mackerel and etc. Among 158 fleets, 20 fleets that had been operating less than six monthes throughout the year have been omitted from the object of the investigation on the fishing power, therefore, in practice, the number of the fleets

Table 55. Number of the fleets investigated in Nagasaki Prefecture.

Tonnage class	One boat purse seine fleet	Two boats purse seine fleet
10~30 tons	4	2
30~50 tons	21	5
50~60 tons	61	1
60~80 tons	34	—
Total	130	8

Table 56. Elements of boats and nets for each tonnage class in 1957-1958.

	Tonnage class	Tonnage	Horse-power	Number of lighting boat	Number of auxiliary boat	Number of fish finder	Number of wireless telephone	Material of net	Length of float line	Depth of net	Number of crew
One boat purse seine fleet	tons 10~30	tons 18.3~29.9	HP 65~100	2	3	1~2	2	Synthetic fiber	m 270~375	m 75	13~25
	30~50	31.4~48.4	100~180	2	1~3	1~3	1~3	Cotton Synthetic fiber	450~630	100~150	31~35
	50~60	50.8~59.9	160~310	2	2~4	1~5	1~5	Synthetic fiber	450~720	110~195	28~35
	60~80	66.2~79.9	270~350	2	2~4	1~5	1~6	Synthetic fiber	550~975	125~225	30~37
Two boats purse seine fleet	10~30	10.1~29.7	12~95	2	3	1~2	0~4	Cotton Synthetic fiber	300	75	53
	30~50	37.7~52.2	140~220	1~3	2~3	1~2	2~5	Synthetic fiber	540	135	40

investigated are 138 and they are sectioned four classes, 10～30 tons, 30～50 tons, 50～60 tons and 60～80 tons, by tonnage and two types of fishing as shown in Table 55. The catch of the fleets which are not the object of this investigation is summed up for the data of the catch.

Elements of the boats and nets of each fleet in the period of 1957 to 1958 which were collected by Nagasaki Branch of the Statistics and Survey Division, and the author's hearing-research from fishermen are shown in Table 56. The values of each fleet are arranged for each term such as tonnage, horse-power and number of light boat and etc., for the range of the min. to the max. for each tonnage class in order to make tabulation short and clear.

The outline of the main fishing-ground is shown in Fig. 30, according to the division by fishermen and fishing bases in Nagasaki Prefecture are shown in Fig. 31.

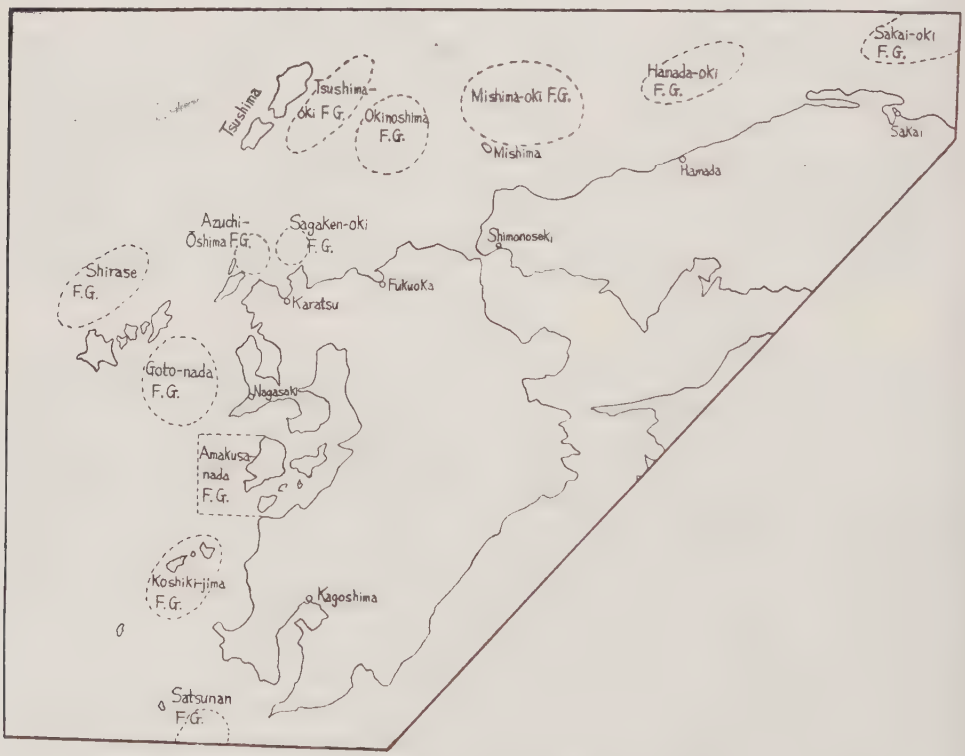


Fig. 30. Fishing-ground of the purse seine fleets in western sea of Japan.

The yearly catch for each species of fish in each fishing-ground, illustrated in Fig. 30, and the monthly catch per fleet are shown in a lump Table 57. In this table the monthly catch off the Saga Prefecture Fishing-ground is included that of the Azuchi Fishing-ground and that of the Kosiki-shima Fishing-ground is excepted from the statistics for poor landing.

Fig. 31. Bases of the purse seine fleets in Nagasaki Prefecture.

Method of measurement of the fishing power

The relative values of the catch for 138 fleets are calculated from the following two kinds of data, according to the method of measurement of the fishing power (2).

1) The catch per day in a lump of four species of fish; sardine, round-herring, and mackerel and horse-mackerel,

2) The catch per month for each species of fish mentioned above.

The calculated relative values of the catch for each fleet owing to limited space are tabulated for each tonnage class on the values of the min. the max. and average as shown in Table 59.

In this study, the calculated values from 1) is called "the relative value of all species of fish" and from 2) "relative values for each species of fish". With these two values the fishing power of the fleets are represented.

Table 57. Catch for species and fishing-grounds during Sep., 1956 to Aug., 1957.

	Sakai				Hamada				Kenjima				Azuchi-Ōshima				Okinoshima			
	S	R	M	H	S	R	M	H	S	R	M	H	S	R	M	H	S	R	M	H
Yearly catch (1000 Kans)	720	28.6	62.4	80.9	26.5	18.3	77.8	392.4	14.1	39.1	431.4	1401.5	16.5	10.5	26.4	380.7	18.4	9.3	27.1	1020.8
Monthly catch per fleet (Km)	5541	3069	4547	5658	5701	3506	6661	12691	757	926	4640	11690	2010	878	1080	7453	1323	493	5060	13950

	Tsushima				Shirase				Gotō				Amakusa				Satsunan			
	S	R	M	H	S	R	M	H	S	R	M	H	S	R	M	H	S	R	M	H
Yearly catch (1000 Kans)	208.5	185.3	773.1	2789.3	298.8	308.1	1659.7	7549.9	373.1	182.6	214.8	1585.8	8.0	8.2	202.9	167.9	4.2	11.3	289.7	355.2
Monthly catch per fleet (Kan)	825	7350	3535	8950	2300	3970	4100	4600	4490	2310	2540	9510	1168	1448	5791	3697	1053	1026	7877	11450

Note: S: Sardine M: Mackerel R: Round-herring H: Horse-mackerel 1 Kan=3.75 kg

Results

Table 58 shows the average relative values of all species of fish for each tonnage class; 10～30 ton class, 30～50 tons class, 50～60 tons class and 60～80 tons class.

According to this table it is clear that the greater the tonnage class, the more the relative value (fishing power) increases and the relative value of 60～80 tons class is about twice as much as that of 10～30 tons class.

Table 58. Relative values of all species of fish for each tonnage class.

Tonnage class	One boat purse seine			Two boats purse seine		
	Average	Max.	Min.	Average	Max.	Min.
10～30 tons	0.54	0.68	0.35	0.31	0.34	0.31
30～50	0.59	0.90	0.27	0.95	1.13	0.72
50～60	0.90	1.63	0.39	0.79		
60～80	1.00	1.61	0.56			

The relation between the fishing power and the fishing facilities and size of nets, Table 56 and Table 58, were compared, and consequently, it is plain that the difference of the fishing power of each tonnage class is due to the size of nets and condition of fishing facilities.

The comparison of the fishing power between one the boat purse seine fleets and the two boats purse seine fleets is also investigated from these tables. The fishing power of the one boat purse seine fleets seems to be superior to that of two boats purse seine fleets in the 10～30 tons class and the 30～50 tons class, but we cannot affirm this result simply because the number of the two boats purse seine fleets is not large enough to compare correctly.

It had been described above that as the production of sardine has been on the decrease in the East China Sea in recent years, large tonnage purse seine fleets have been catching mainly horse-mackerel and mackerel.

However, as in the Tushima, Sirase, Goto-nada Fishing-ground there has been a little landings of sardine as shown in Table 58, the purse seine fleets operating in these areas have been in use with nets of 2.75～3.80 cm mesh size for the capture of sardine together with horse-mackerel and mackerel. (The suitable mesh size of a purse seine to catch only sardine is 2.76 cm and to catch mackerel and horse-mackerel is 3.80～4.36 cm).

The swimming-depth of sardine is generally shallower than 50 m in depth, but that of horse-mackerel and mackerel often reaches to 150 m in depth. Furthermore, horse-mackerel and mackerel do not rise readily to the sea-surface even with aid of fish luring lamps, especially in winter. Thus, there is a marked difference in the swimming-depth between the sardine and the horse-mackerel and mackerel.

Nets of fleets less than 50 tons have been smaller in both depth and length

than fleets of over 50 tons, neverthless the mesh size of both is the same because the catch of horse-mackerel and mackerel of the former is by far less than that of the latter. Therefore, it is no wonder that fleets less than 50 tons have been catching mainly sardine rather than horse-mackerel and mackerel.

Following Table 59, the relative values of the catch for sardines (sardine and round-herring) of the 10~30 tons and the 30~50 tons classes are larger than that of 50~60 tons class, but as for horse-mackerel and mackerel this situation is reversed, and the 50~60 tons class is intermediate between the 10~50 tons class and the 60~80 tons class for each species of fish.

Table 59. Relative values for each species of fish for each tonnage class.

	Tonnage class	Sardine	Round-herring	Mackerel	Horse-mackerel
One boat purse seine fleet	10~30 tons	1.54	2.04	0.47	0.67
	35~50	1.27	1.26	0.84	0.78
	50~60	0.85	1.03	1.00	0.97
	60~80	0.66	0.77	1.18	1.13
Two boats purse seine fleet	10~30	1.83	0.76	0.13	0.76
	30~50	0.14	0.76	1.23	1.00

In a similar way, the fishing power of the two boats purse seine fleets is considered; the relative values for each species of fish of the 10~30 tons class is larger in comparison with that of the 30~50 tons class for sardine and round-herring, and as for horse-mackerel and mackerel this situation is reversed, similar to the results obtained for the one boat purse seine fleets.

§ 2. The Fishing Power of the Purse Seine Fleets Operating in the East China Sea

The fishing power of the purse seine fleets in Nagasaki Prefecture has already been investigated in the previous paragraph. In the East China Sea numerous purse seine fleets operate, not only the Nagasaki Prefecture fleets but also other prefectures fleets such as the Kagoshima, Kumamoto, Saga, Fukuoka and Yamaguchi Prefectures fleets have been operating. In this study, firstly, the fleets based in above six prefectures including Nagasaki have been investigated in regard to their fishing power. Secondly, as the fleets based in Yamaguchi, Saga, Fukuoka and Kumamoto Prefectures are operating in common fishing-grounds with the Nagasaki Prefecture fleets, the fishing power between the Nagasaki Prefecture fleets and the other prefectures fleets have been compared with one another. (The reason that this comparison has been made will be described below.) Furthermore, in Yamaguchi Prefecture, as the two boats purse seine fleets have been operating together with the one boat purse seine fleets

in the same fishing-grounds the fishing power of these two fleets are also compared.

Data

The data used in this investigation is the daily catch for each species of fish, sardine, round-herring, horse-mackerel and mackerel and for each fishing-ground illustrated in Fig. 30 during 1955, supplied by the Branch of Statistics and Survey Division in each prefecture. The record on the tonnage of the seiners and the horse-power of their engines was also collected by the above Branch.

The numbers of the fleets investigated in each prefecture are shown in Table 60, divided into four ton classes of seiners; 10～30 tons, 30～50 tons, 50～60 tons and 60～80 tons classes and two kinds of fishing types.

The outline of the fishing-ground of each prefecture fleet is the same as shown in Fig. 30.

Table 60. Number of fleets investigated in each prefecture.

Prefecture \ Tonnage class	Tons 10～30	30～50	50～60	60～80	Total
Kagoshima	—	9	4	—	13
Kumamoto	—	29	1	5	35
Nagasaki	—	12	11	2	25
Saga	—	7	1	—	8
Fukuoka	—	2	4	—	6
Yamaguchi (One boat purse seine)	1	6	17	11	35
Yamaguchi (Two boats purse seine)	4	11	—	—	15
Total	5	76	38	18	137

Results

a. Number of days at sea and catch for each fishing-ground

The number of days at sea for each prefecture fleet and for each fishing-ground are shown in Table 61. According to this table, the number of days at sea in a year in Kenjima, Okinoshima and Tsushima Fishing-grounds is very great, but in Hamada, Saga and Shirase Fishing-grounds it considerable less.

The catch for each species and for each fishing-ground throughout a year are shown in Table 62. From this table and Table 61 it is found that the most productive of the fishing-grounds in the whole are Kenjima, Tsushima and Okinosima, but Hamada, Saga, Shirase and Azuti-Oshima Fishing-grounds are rather poor and the production of sardines in each fishing-ground is markably less than that of horse-mackerel and mackerel. In the catch of horse-mackerel and mackerel few differences exist.

Table 61. Number of days at sea during a year in each fishing-ground.

Fishing-ground / Prefecture	Sakai	Hamada	Kenjima	Okinoshima	Azuchi-Ōshima	Tsushima
Nagasaki	129	16	343	260	46	454
Yamaguchi	376	177	2000	600	—	571
Kumamoto	—	—	—	—	—	—
Fukuoka	—	2	145	134	234	—
Saga	36	6	48	162	250	85
Kagoshima	—	—	—	—	—	—
Total	541	201	2536	1156	530	1110

	Saga	Sirase	Gotō	Amakusa	Koshikijima	Satsunan
Nagasaki	11	180	376	16	5	12
Yamaguchi	9	6	39	1	17	—
Kumamoto	—	—	90	824	427	164
Fukuoka	—	—	—	8	—	—
Saga	189	—	—	—	—	—
Kagoshima	—	—	—	1	430	207
Total	209	186	505	850	879	383

Table 62. Total catch in unit of 1000 kans through a year in each fishing-ground.

Fishing-ground / Species	Sakai	Hamada	Kenjima	Okinoshima	Azuchi-Ōshima	Tsushima
All species	1547	473	5427	3100	184	2027
Sardine	257	47	217	621	48	124
Horse-mackerel	515	95	2714	1239	129	1216
Mackerel	619	331	2170	1240	3	653

	Saga	Sirase	Gotō	Amakusa	Koshikijima	Satsunan
All species	315	534	1110	1443	1099	894
Sardine	264	98	109	426	215	190
Horse-mackerel	32	336	624	481	525	410
Mackerel	19	121	216	136	221	260

b. Fishing power of the purse seine fleets in each prefecture

The fishing power of the purse seine fleets in each prefecture is calculated by the same method in the previous study on the following two items from the data of the catch per day;

1) Relative value of all species of fish,
2) Relative value for each species of fish.

The relations between these relative values and the tonnage, and the horsepower of the seiners in each prefecture are shown in Tables 63~67, respecively.

Table 63. Relative value of the catch, the Kagoshima Prefecture fleets.

Tonnage class	Horse power of engine	Relative values of the catch			
		All species	Sardine	Horse-mackerel	Mackerel
30~50 tons	85~200 HP	0.98	2.49	0.77	0.64
50~60	180	0.80	1.92	0.81	0.43

Table 64. Relative value of the catch, the Saga Prefecture fleets.

Tonnage class	Horse power of engine	Relative values of the catch			
		All species	Sardine	Horse-mackerel	Mackerel
30~50 tons		0.83	1.50	0.81	0.93
50~60		0.93	1.00	1.45	0.82

Table 65. Relative value of the catch, the Nagasaki Prefecture fleets.

Tonnage class	Horse power of engine	Relative values of the catch			
		All species	Sardine	Horse-mackerel	Mackerel
30~50 tons	80~160 HP	1.09	2.19	1.74	0.86
50~60	200~310	1.08	1.37	1.54	1.02
60~8.	250~350	1.62	0.98	1.97	1.71

Table 66. Relative value of the catch, the Kumamoto Prefecture fleets.

Tonnage class	Horse power of engine	Relative values of the catch			
		All species	Sardine	Horse-mackerel	Mackerel
10~20 tons	25 HP	0.23	0.21	0.36	0.35
30~50	90~140	0.74	1.50	1.05	1.26
50~60	135~225	1.68	1.02	1.56	1.57

Table 67. Relative value of the catch, the Yamaguchi Prefecture fleets.

Tonnage class	Horse power of engine	Relative values of the catch			
		All species	Sardine	Horse-mackerel	Mackerel
Two boats purse seine fleets					
10～30 tons	90 HP	0.46	0.12	0.46	0.59
30～40	90～250	0.79	0.45	0.98	1.01
One boat purse seine fleet					
40～50 tons	100～250 HP	0.64	1.27	0.90	0.95
50～60	170～250	0.91	1.18	1.01	1.17
70～80	250～350	0.97	0.58	1.24	0.81

In these tables, through relative values had been calculated for every fleet in each prefecture, each tonnage class arranged with average values.

From these tables, generally speaking, it is found that the fishing power of the fleets correlates closely to the tonnage of the seiners and the horsepower of the engines, namely, the larger the tonnage class, the greater the fishing power of the fleets. It is also found that for the relative values on sardine, the smaller tonnage classes, 10～30 tons, and 30～50 tons, show higher values than the large tonnage classes, 50～60 tons and 60～80 tons, but on mackerel and horse mackerel, this situation is reversed. This reason had been already explained in the previous paragraph.

Of course, the fishing facilities of the fleets and the size of the nets is an influence on the fishing power of fleets, yet in this study this data has not been investigated.

c. Comparison of the fishing power between one boat and two boats purse seine fleets

In Yamaguchi Prefecture, as one boat seine fleets and two boats seine fleets are operating together in the same fishing-ground, it is possible to compare the fishing power between them (Table 67).

Following this table, as the one boat seine fleets are over 40 tons, but the two boats seine fleets are all less than 40 tons, it is difficult to compare them on the same tonnage class.

But, this table has suggested that if the fishing power of the two boats and the one boat purse seine were compared on the same tonnage class, the former would have been superior to the latter, for even the 30～40 tons class of the former is better than 40～50 tons class of the latter on the relative values of all species of fish.

This situation may be recognized from Table 69, in which it is shown that the catch per day and the fleet of all species of two boats purse seine

Table 68. Catch and number of days at sea by one boat and two boats purse seines.

	One boat purse seine fleets			
	All species	Sardine	Horse-mackerel	Mackerel
Catch per day and fleet	2275 Kan	230	1229	816
Number of days at sea per month	15.2	—	—	—
Catch per month and fleet	34500 Kan	3500	18630	12400
	Two boats purse seine fleets			
Catch per day and fleet	2443 Kan	254	1235	854
Number of days at sea per month	13.1	—	—	—
Catch per month and fleet	32000 Kan	3320	16300	11200

fleets is somewhat larger than that of the one boat purse seine fleets. But this table also shows that the number of days at sea of one boat purse seine fleets is more frequent by about two days per month than of the two boats purse seine fleets, and then, regarding the catch per month and the fleets, the one boat purse seine fleets are superior to the two boats purse seine fleets, The difference in the number of days at sea between the one boat and two boats purse seine fleets is mainly caused by the weather, especially, the wind and wave, because two boats purse seiners are always operating as a pair, so that, when the sea is running high one of two boats purse seiners is likely to run against the other while they are setting and hauling net.

d. Comparison of the fishing power between the Nagasaki Prefecture fleets and other prefecture fleets

The fishing antogonisum arising in the East China Sea between the one boat purse seine and the two boats purse seine or other coastal fisheries has been mentioned in the previous paragraph.

In recent years, the one boat purse seine fleets based in each prefecture, which had been operating off Tushima and Saishu-to, have been compelled to go fishing off other prefectures mutually, because the Rhee Line was set by Korea since 1952. Above all, the Nagasaki Prefecture fleets have been more numerous and have installed more efficient fishing gears than other prefectures fleets and furthermore as they often fish off Yamaguchi, Simane, Saga, Fukuoka and Kumamoto, the former has, naturally, become a menace to the latter. Such fishing operations are the origin of the antogonisum in each prefecture.

Hence, in this study, the fishing power between the Nagasaki Prefecture fleets and other prefectures fleets, in Yamaguchi, Saga, Fukuoka and Kumamoto, has been compared in order to supply fundamental data for the management of the fishery.

Relative values of the catch already shown in Tables 63~67 have been

calculated from the data on the catch produced from the whole of fishing-grounds. But, for example, when the comparison of the fishing power between the Nagasaki Prefecture fleets and the Yamaguchi Prefecture fleets is made, as the Yamaguchi Prefecture fleets had been not operating in Azuchi-Oshima and Satsunan Fishing-ground, while the Nagasaki Prefecture fleets had been operating in these fishing-ground, it should be done with re-calculated relative values excepting the catch produced from Azuchi-Oshima and Satunan Fishing-grounds.

Similarly, the ratio of the fishing power of the Nagasaki Prefecture fleets to the Saga, Fukuoka and Kumamoto Prefectures fleets was calculated for each tonnage class as shown in Table 69.

Table 69. Comparison of relative values of the catch between the Nagasaki Prefecture fleets and other prefectures fleets

Species / Tonnage class	All species	Sardine	Horse-mackerel	Mackerel
35~40 tons	1.02/0.83	2.41/0.61	1.41/1.00	0.71/0.93
40~50	0.91/0.64	1.91/1.23	1.37/0.52	0.82/1.03
50~60	1.02/0.92	1.71/1.13	1.34/1.00	1.02/1.31
70~80	1.42/0.72	0.62/0.52	1.51/1.23	1.24/0.62

Ratio of relative value of the catch of the Nagasaki Prefecture fleets to that of the Yamaguchi Prefecture fleets.

Species / Tonnage class	All species	Sardine	Horse-mackerel	Mackerel
30~40 tons	1.12/0.81	2.93/2.44	1.04/0.43	0.82/0.23
40~50	0.92/1.82	1.36/2.12	1.54/2.02	1.13/2.34
50~60	1.05/0.82	0.94/1.94	1.23/0.88	1.03/0.42

Ratio of relative values of the catch to the Saga Prefecture fleets.

Species / Tonnage class	All species	Sardine	Horse-mackerel	Mackerel
40~50 tons	1.21/0.83	1.75/0.72	1.23/1.00	1.56/1.42
50~60	2.03/0.93	1.44/0.92	1.93/1.42	1.91/0.62

Ratio of relative value of the catch to the Fukuoka Prefecture fleets.

Species / Tonnage class	All species	Sardine	Horse-mackerel	Mackerel
30~50 tons	1.18/0.96	1.38/1.50	1.26/1.01	1.4./1.34
50~60	1.52/1.68	1.39/1.01	1.28/1.15	1.82/1.56

Ratio of relative value of the catch to the Kumamoto Prefecture fleets

According to this table the fishing power of the Nagasaki Prefecture fleets is generally more or less superior to that of the other prefectures fleets for each tonnage class with two exception, the 40～50 tons class of Kumamoto Prefecture fleets and the 50～60 tons class of Saga Prefecture fleets.

§ 3. The Comparison of the Fishing Power between Coastal Two Boats Purse Seine Fleets and Lampara Net Fleets

Two boats purse seines in the East China Sea have been divided into two types; the one is over 20 tons class, which is operating in offshore water together with one boat purse seine fleets, the other is less 20 tons class, which is operating in coastal water together with lampara nets and other small fishing boats.

Lampara nets have been in use to catch sardine, horse-mackerel, mackerel and other fish along the coast of Kumamoto and Nagasaki Prefectures. In the period of 1956, lampara net fleets were 176 in number and coastal two boats purse seine fleets were 248 in number (the both are less 20 tons class) in the East China Sea and these two nets fisheries have held a chief position in coastal fisheries of this regions.

The fishing-grounds of the both are within the limit of 10 miles from shore, and coastal two boats purse seine fleets are usually carrying out fishing a little more off than lampara nets fleets.

In this study, the fishing power of the coastal two boats purse seine fleets (forward, they are called as purse seine fleets) and lampara net fleets in Nagasaki Prefecture has been compared with to make a fundemental data of the management of the fishery.

Data

Data of the catch of the purse seine fleets and lampara net fleets during a year from Sep. 1956 to Aug. 1957 is supplied by Nagasaki Branch of the Statistic and Survey Division. The main species of fish caught by the two kinds of fleets are sardine and anchovy. Sardine is caught in from May to June and Anchovy from Sep. to Nov.; other species of fish caught are horse-mackerel and saury-pike.

Method of the comparison

When the fishing power of two kinds of the fleets is compared by the data of the unit catch, we have to confirm by analysis of the data whether or not they are operating at the same time and place and catching common species of fish. For this purpose, at first we sellected common four bases of two kinds of the fleets from 14 bases of purse seine fleets and 10 bases of lampara net fleets in Nagasaki Prefecture. Thus, as common bases, Hasuka, Saseho, Mie, and Kōnoura were selected and the situation of these bases are shown in Fig. 32.

Secondly, the proportion of species of fish caught in the total catch was compared with two kinds of the fleets as shown in Tables 70～73, respectively, and finally, body-length of sardine and anchovy caught was also compared with

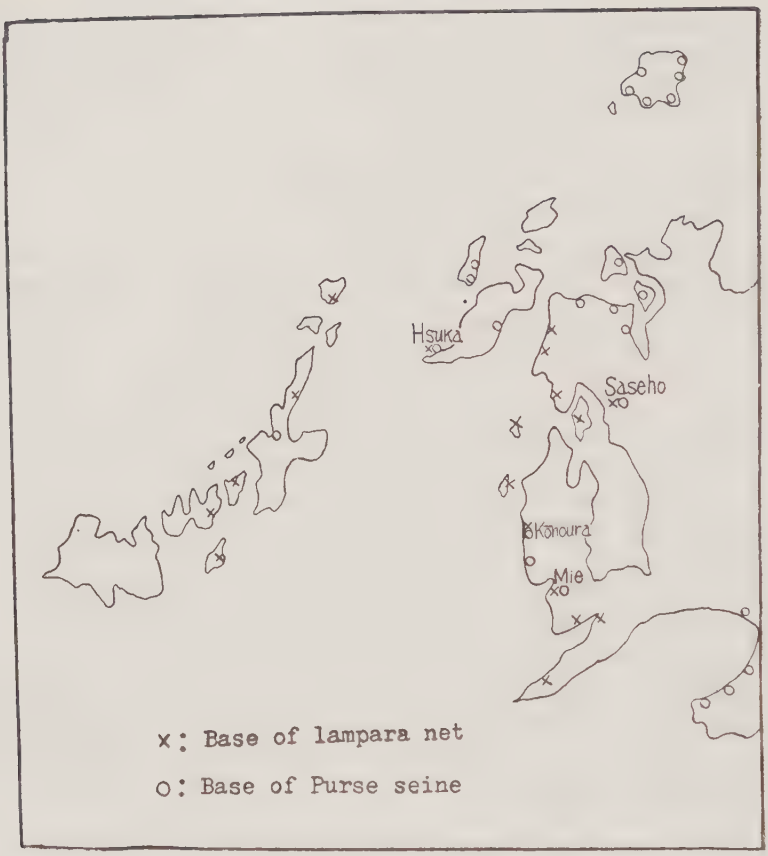


Fig. 32. Fishing bases of lampara net fleets and purse seine fleets in Nagasaki Prefecture.

Note: ×: Lampara net fleet base
○: Purse seine fleet base
□: Common base of lampara net and purse seine net fleets

them, to examine whether the selectively of two kinds of the nets to fish is similar or not through these examinations.

Following Tables 70~73, the proportion of species of fish caught by the purse seines relatively corresponds to that by the lampara nets in both Kōnoura and Mie, while in both Saseho and Hasuka there is a little difference in this correspondence, but which is not considerably great.

Table 74 shows the results on the measurement of boby-length of fish caught by both kinds of the nets, this measurement had been made by the Seikai Regional Fisheries Research Station.[46),47)] Following this table, the range of body-length of sardine caught for both kinds of the nets closely corresponds in each month and as for anchovy it may be seen similar to the case of sardine, but as for anchovy it may be not said with certainly because the measurement of body-length had been continuously not performanced month by month.

Table 70. Proportion of species of fish caught in total catch, at Saseho.

	Species \ Month	Feb.	Mar.	May	June	July	Sep.	Oct.	Nov.	Dec.
Two boats purse seine	Sardine	% —	% —	% 45	% 14	% —	% —	% —	% —	% —
	Round-herring	—	—	—	50	—	—	—	—	—
	Anchovy	49	87	43	39	46	97	95	95	100
	Horse-mackerel	51	13	12	—	50	2	4	5	—
	Mackerel	—	—	—	7	4	1	1	1	—
	Average catch (Kan)	155	9	565	214	351	215	322	243	228
Lampara net	Sardine	—	—	18	3	—	—	6	—	—
	Round-herring	—	—	46	55	—	1	18	—	—
	Anchovy	100	99	30	—	73	45	49	100	82
	Horse-mackerel	—	1	6	42	12	27	27	—	18
	Mackerel	—	—	—	—	15	27	—	—	—
	Average catch (Kan)	283	164	313	226	258	229	439	270	320

Note: Average catch is the catch per boat in all species.

Table 71. Proportion of species of fish in total catch, at Hasuka.

	Species \ Month	May	June	July		May	June	July
Two boats purse seine	Sardine	% 32	% 71	% 51	Lampara net	% 90	% 44	% 84
	Round-herring	—	15	24		—	—	—
	Anchovy	9	14	23		9	47	16
	Horse-mackerel	59	—	2		1	9	—
	Average catch (Kan)	299	365	404		212	322	394

From the two above points of view, it might has been confirmed that the purse seine and the lampara not have the same selectivity of fish in species and body-length. In addition, as the fishing-grounds of the both are almost the same, the comparison of the fishing power between the purse seine and the lampara net with the unit catch would be recognized as justifiable.

The fishing boats and fishing gears of two kinds of the fleets are compared with in Table 75. It is seen from this table that the tonnage of netting boat and the size of net of the purse seine fleets are a little larger than those of the lampara net fleets.

Table 72. Proportion of species of fish in total catch, at Mie.

	Species \ Month	May	June	Oct.	Nov.	Dec.		May	June	Oct.	Nov.	Dec.
		%	%	%	%	%		%	%	%	%	%
Two boats purse seine	Sardine	41	57	81	11	18	Lampara net	30	45	80	—	—
	Round-herring	—	39	9	80	49		—	40	9	100	100
	Anchovy	38	4	8	—	33		26	15	8	—	—
	Horse-mackerel	18	—	2	—	—		12	—	2	—	—
	Others	3	—	—	9	—		32	—	1	—	—
	Average catch (Kan)	2290	2280	2780	1100	1760		1600	1730	1560	1000	1460

Table 73. Proportion of species of fish in total catch, at Kōnoura.

	Species \ Month	May	June	Sep.	Oct.	Nov.		May	June	Sep.	Oct.	Nov.
		%	%	%	%	%		%	%	%	%	%
Two boats purse seine	Sardine	21	30	71	55	34	Lampara net	18	29	42	61	21
	Round-herring	—	—	20	25	60		—	—	41	15	51
	Anchovy	44	42	8	12	6		48	45	11	24	19
	Horse-mackerel	35	28	—	8	—		34	26	6	—	6
	Others	—	—	1	—	—		—	—	—	—	3
	Average catch (Kan)	416	353	684	1378	1049		350	320	839	1251	640

Table 75. Elements of fishing boats and fishing gears of purse seine and lampara net.

Fishing boat	Lampara net				Two boats purse seine			
	Number of boat	Tonnage (ton)	Horse power of engine	Number of fishermen	Number of boat	Tonnage (ton)	Horse power of engine	Number of fishermen
			(HP)				(HP)	
Netting boat	2	5	No engine	20	2	5	No engine	34
Auxiliary boat	2	4~5	15	8	2	—	〃	4
Towboat	2	8.3	32	8	2	6	10~15	6
Lighting boat	2	2.8	8	6	2	5	8	5
Fish finder boat	—	—	—	—	1	10	8	5
Total	8	—	—	42	9	—	—	54
Fishing gear: Length of net (m)	242				315			
Fishing gear: Depth of net (m)	55				75			

Note: Fish finding boat is the one which equipes fish finder.
In lampara net fishery towboat does duty for a fish finding boat.

Table 74. Range of body-length of sardine and anchovy caught in each month by purse seine and lampara net.

Species and fishing-groung	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
(Sardine) Nagasaki	Two boats purse seine	cm 18.5~220	13.5~23.0	—	—	3.5~7.0	5.5~8.0	8.0~12.0	10.5~15.5	10.0~15.5	12.5~16.5	12.5~15.5	14.0~17.0
	Lampara net	cm 19.0~23.0	—	—	—	3.5~7.0	5.5~7.5	8.0~12.0	10.5~15.5	10.0~15.5	12.5~16.5	12.5~15.5	14.0~17.0
(Anchovy) Gotō	Two boats purse seine	—	—	—	—	—	—	—	cm 8.5~10.0	8.0~13.5	9.0~13.5	10.5~14.0	—
	Lampara net	—	—	—	—	—	—	cm 9.5~12.5	—	9.0~11.5	—	—	—

Results

The result of the comparison of the catch per boat and by both kinds of nets in four bases is shown in Fig. 33. In this figure, the numbers of the purse seine fleets investigated and the lampara net fleets investigated for bases are as follows;

Base	Purse seine fleets	Lampara net fleets
Saseho	3	7
Hasuka	4	9
Mie	1	1
Konoura	2	2

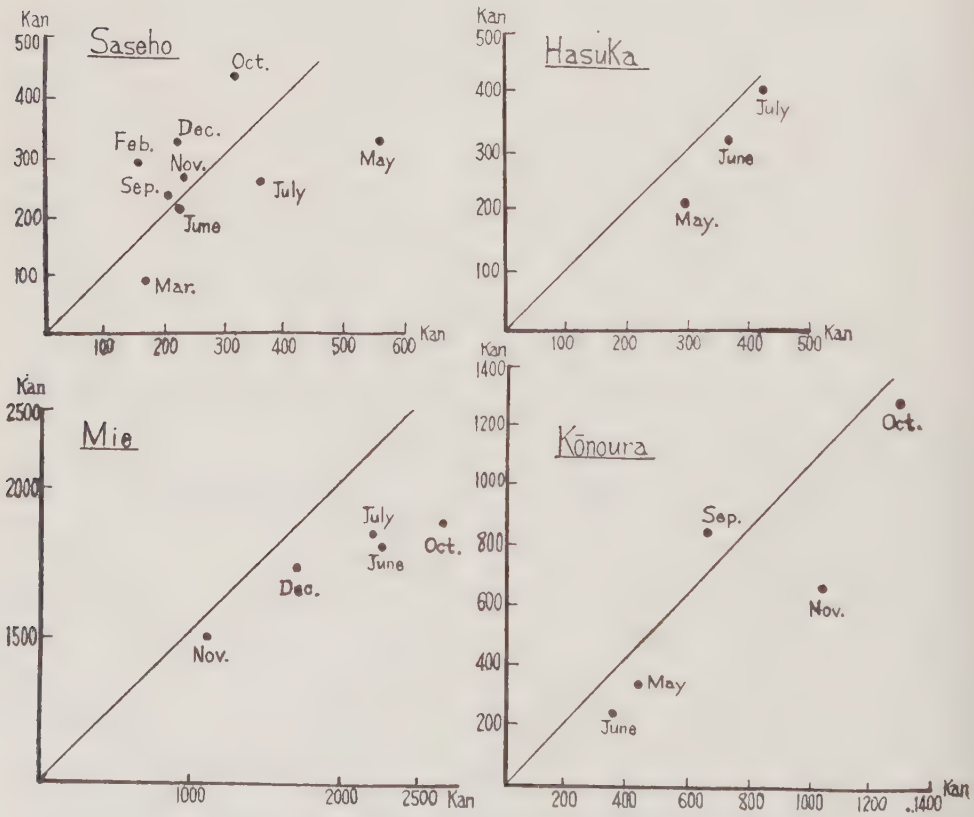


Fig. 33. Comparison of the catch per fleet and day between purse seines and lampara nets.

Note: The axis of perpendicular indicates the catch of the lampara net and of abscissa indicates that of the purse seine.
1 kan=3.75 kg

Table 77. Comparison of the daily catch between purse seines and lampara nets. (By Murakami)

Area	I Ôyamase fishing-ground								II Off Kabasima																
Distance from base	SE・7	SE・12	SE・10	E・4	E・5	S・12	SE・8	E・5	4	6	4	5	6	3	4	6	4	4	3	4	6	3	3½	6	5	6
Date	'51 Sep. 21	〃 25	〃 26	〃 29	Oct. 1	〃 2	〃 2	〃 2	'51 Aug. 10	〃 13	〃 15	〃 18	〃 20	〃 20	〃 23	〃 25	〃 30	Sep. 3	〃 4	〃 5	〃 8	〃 8	〃 13	〃 20	〃 28	〃 30
Catch (Kan) Purse seine	2400	784	800	1600	—	—	2400	—	—	3600	—	—	4000	—	—	—	—	—	—	—	4000	2000	—	—	—	—
Catch (Kan) Lampara net	—	—	—	—	200	800	—	160	4000	—	2400	2800	—	3400	2800	2400	2800	3320	2800	3400	—	—	2520	2800	2400	3600

At Sasebo, the catches of the purse seine and the lampara net are very close, but at other bases the catch of the purse seine is a little greater than that of the lampara net.

The results gained from Fig. 33 are tabulated again as shown in Table 76.

According to Murakami's report* showed in Table 77, when two kinds of fleets operated in slightly offshore areas (Area 1) in the period from Sep. 21 to Oct. 1951, the ratio of the daily catch of sardine by the purse seine to that of the lampara net was about 4:1, but when both fleets operated close to shore (Area II), in the period of from Aug. 10 to Sep. 30, this ratio vaired to about 4:3.

Table 76. Comparison of the catch between purse seine and lampara net

Base	Catch per day and fleet (Kan)		
	Purse seine (A)	Lampara net (B)	A/B
Saseho	274	277	0.99
Hasuka	356	309	1.15
Mie	2030	1470	1.38
Kamiura	776	680	1.14

Consequently, the catch of the lampara nets seems to be slightly less than that of the purse seine, but if the unit of the catch is computed in terms of the catch per man, as the number of the crew of a lampara net fleet is about 40, while that of a purse seine fleet is about 50, there is almost no difference between the both.

VIII. The Fishing Power of the Purse Seine Fishery for Skipjack and Tuna

§ 1. The Relation of Behaviours of Skipjack and Tuna to Their Catches

Recently, skipjack and tuna purse seine fisheries have made rapid progress on the coast of the north eastern sea areas of Japan. In this study, the relation of behaviours of skipjack and tuna to their catches and also the relation of grouping of fish in shoals to their catches were investigated and at the same time the difference of the fishing power was also pursued between one boat seine and two boats seine fleets.

Grouping and behaviours of shoal

The data were obtained from the fishing diary of the purse seine fleets of Taiyo Gyogyo Company, Ltd. in the periods from 1953 to 1957.

The number of the fleets investigated and their tonnages changed by years

* Unpublished report; he is a head of Resources Division of Seikai Regional Fisheries Research Station.

Table 78. Number of fishing fleets for each year.

Year	One boat seine	Two boats seine
	tons	tons
1953	8 (99.4~189.5)	0
1954	7 (99.4~189.5)	0
1955	2 (148.6~178.5)	2 (123.0~163.5)
1956	2 (148.6~178.5)	3 (123.0~163.5)
1957	2 (148.6~178.5)	3 (80.9~164.6)

as shown in Table 78.

The species of fish treated in this study are blue-fin-tuna, young-tuna, yellow-fin-tuna, sword-fish, skipjack and their mixeds shoal and the frequency of runs detected through the investigation periods are shown in Table 79.

Table 79. Number of investigation runs for each species of fish.

Species of fish	Frequency of runs detected
Blue-fin-tuna	716
Sword-fish	28
Yellow-fin-tuna	191
Young-tuna	126
Skipjack	326
Mixed shoal	102

The grouping of shoals is divided into three classes such as great, intermediate and small groups and furthermore the type of shoals is classified ten types from the viewpoint of their behaviours as below.

The shoal with no association
The shoal with bird
The shoal with jumping members
The shoal with baits
The shoal swirling near the sea-surface
The shoal baiting near the sea-surface
The shoal with timber
The shoal with shark
The shoal with whale
The shoal of indistinct type

The features of behaviors of these types except the shoals with timber, shark and whale are explained by the hearing-research from fishermen as follows.

The shoal with no association: This shoal is merely swimming near the sea-surface with no association and it is found easy by the naked eye.

The shoal swirling near the sea-surface: This shoal is the crowded fish near the sea-surface without jumping individuals on the sea-surface. They are swirling roundly with slow speed. Generally, they will become such condition at full stomack.

The shoal with jumping numbers: The main body of this shoal is swimming in the middle layer of sea or near the sea-surface, but some fish of this shoal sometimes jump out on the sea-surface. They often appear in the boundary waters between the Kuroshio (warm) and the Oyashio (cold) currents. This type shows the highest numbers of detection in this study.

The shoal with bait: This type is pursing small fish such as anchovy, squid, mackerel-pike and small mackerel for food and it is said that the capture of the shoal pursing anchovy is most easy.

The shoal baiting near the sea-surface: This shoal is one kind of the shoal with bait. As bubbles spread all over the sea-surface it can be distinguished from the shoal with bait.

The numbers of investigation runs for each species of fish during the periods of investigations is shown in Table 78. Following this table it is found that main species of fish caught by the purse seine fleets are skipjack, blue-findtuna and yellow-fin-tuna or their mixed shoal. Generally the mixed shoal is composed of skipjack and blue-fin-tuna, but sometimes it is composed of skipjack and yellow-fin-tuna.

Fishing-ground and fishing season

The purse seine fleets based on Onahama, Siogama and Ishinomaki in Iwate Prefecture have been going out to off 50~60 miles from the coast of the Pacific Ocean.

Generally this fishery is beginning from late May or early June and ends at late October annually. Fishing-ground of it removes to north with

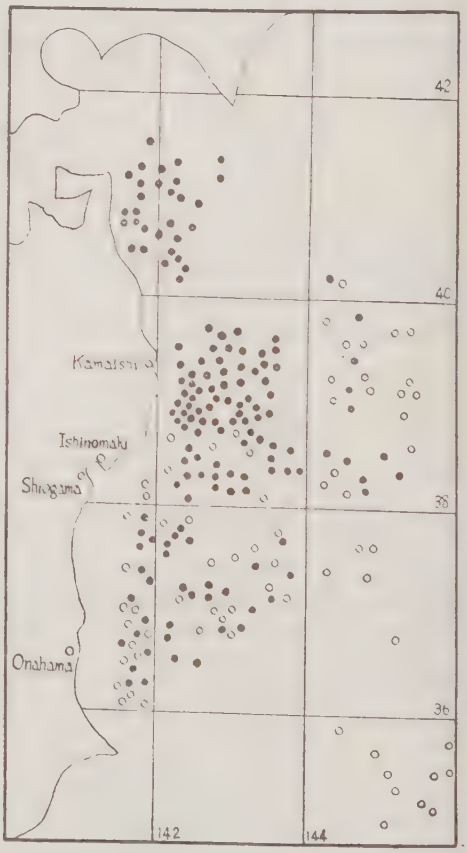


Fig. 34. Fishing-ground in 1957

Note:
○: Hurling place of one boat purse seiner
●: Hurling place of two boats purse seiner

process of fishing season and at last, occasionally, it appears to near Erimo point. As one example the fishing-ground in 1957 is shown Fig. 34.

In this figure, hauling places are shown dividing into one boat purse seine fleets and two boats purse seine fleets. Sometimes skipjack angling fishery which is the most important one for the capture of skipjack in Japan is carried out in the common fishing-ground of the purse seine fleets, but in most cases the fishing-ground of it is further east from the 145th degree of east longitude. In general, it is said that the fishing-grounds of one boat purse seine fleets and two boats seine fleets are almost the same, but following Fig. 34 itis seen that one boat seine fleets are going out to a little distance away than two boats seine fleets.

The number of days at sea and pursing between one boat and two boats seine fleets are almost no difference as shown in Table 80.

But the operation hours (from layout to hauling net) of one boat seine is longer than that of two boats seine as shown in Table 81. This may be due,

Table 80. Number of days at sea and pursing.

	Name of fleet		May	June	July	Aug.	Total
One boat purse seine fleet	A	Number of days at sea (D)	4	13	16	5	38
		Number of pursing (P)	4	16	21	6	47
	B	D	4	12	14	8	38
		P	5	15	15	10	45
Two boats purse seine fleet	C・D	D	1	11	17	8	37
		P	1	13	21	9	44
	E・F	D	2	12	18	6	38
		P	2	12	19	6	39
	G・H	D	2	11	16	8	37
		P	2	13	22	8	45

Table 81. Average operation hours.

	Name of fleet	Operation hours (average)	
		With catch	With no catch
One boat purse seine fleet	A	4° 36′	2° 36′
	B	4° 27′	2° 36′
Two boats purse seine fleet	C・D	7° 59′	4° 12′
	E・F	6° 26′	5° 13′
	G・H	5° 48′	3° 26′

naturally, to the difference of size of the nets, the one boat seine is approximatly 1500 m in length of float line and the two boats seine is approximatly 1000 m in same unit.

Results

a. Relation between behaviours of various of fish and rate of the number of pursing with catch

As skipjack and tuna are swimming more quickly than horse-mackerel, mackerel and sardine and they are easily frightened by a net, a large proportion of the shoal is liable to escape from the net no matter how much care is taken while the net is being set.

By the author's investigation, the number of pursing with catch for anchovy purse seine in Tokyo Bay is approximately 75% of the total numbers of pursing, and that of horse-mackerel and mackerel purse seine is approximately 85% with aid of fish luring lamps.

For skipjack and tuna purse seine the number of pursing with catch is below one half of total number of pursing as described in the later and the time of operation is about three to five hours, which is three to five times as longer as that of the purse seine for sardine, horse-mackerel and mackerel.

In this study, the rate of number of pursing with catch (f) which is shown by the ratio of the number of pursing with catch (n) to total number of pursing (N) is used as an inxex of measurement whether the shoal is caught with ease or not.

Table 82. Number of pursing with catch for each range of catch and various species of fish

Species	Range of catch						Number of pursing with catch
	0 Kan	>100 Kan	100>500 Kan	500>1000 Kan	500>2000 Kan	1000<2000 Kan	
Blue-fin-tuna	505	10	34	39	37	99	219
Sword-fish	14	3	3	2	0	0	8
Yellow-fin-tuna	82	4	33	20	25	33	105
Young-tuna	84	2	9	11	9	10	41
Skipjack	135	10	46	39	46	55	196
Mixed shoal	38	4	14	15	6	23	62

The range of the catch per pursing is divided into six ranks; 0 kan, >100 kans, >500 kans, >1000 kans, >2000 kans and over 2000 kans. The number of pursing with catch for each rank is shown in Table 82. Following this table the number of pursing with catch less 100 kans rank except 0 kans rank is relatively less compared with that of each rank of over 100 kans.

* 1 Kan=3.75 kg

Table 83. Values of f and C for behaviours of various species of fish.

Species		S_a	S_b	S_c	S_d	S_e	S_f	S_g	S_h	S_i	S_j
Blue-fin-tuna	n/N (f)	6/23 (0.26)	61/160 (0.38)	82/366 (0.22)	19/32 (0.60)	23/50 (0.46)	8/18 (0.44)	—	—	2/2 (1.00)	18/65 (0.28)
	(Kan) C	2590	3510	2640	3640	3750	3920	—	—	6750	3730
Sword-fish	n/N (f)	1/1 (1.00)	3/6 (0.50)	3/12 (0.25)	0/3	—	—	—	—	—	—
	C	240	640	80	0	—	—	—	—	—	—
Yellow-fin-tuna	n/N (f)	1/2 (0.50)	17/33 (0.51)	46/97 (0.47)	8/16 (0.50)	8/12 (0.57)	4/4 (1.00)	1/1 (1.00)	—	2/3 (0.67)	12/23 (0.56)
	C	2500	800	1260	1070	1240	3840	540	—	3630	470
Young-tuna	n/N (f)	1/13 (0.07)	6/25 (0.24)	16/48 (0.33)	6/12 (0.50)	9/16 (0.56)	—	—	1/3 (0.33)	—	2/9 (0.22)
	C	1880	2500	1580	900	1970	—	—	1970	—	4600
Skipjack	n/N (f)	21/42 (0.50)	21/57 (0.54)	27/53 (0.51)	22/27 (0.81)	34/51 (0.67)	21/29 (0.27)	3/4 (0.75)	10/11 (0.90)	7/12 (0.58)	14/40 (0.35)
	C	1460	1510	990	1430	1150	1850	3190	2460	1640	2900
Mixed shoal	n/N (f)	5/8	8/12 (0.67)	16/26 (0.61)	5/6 (0.83)	10/16 (0.62)	3/4 (0.75)	2/2 (1.00)	2/2 (1.00)	5/6 (0.83)	8/20 (0.30)
	C	1810	1390	2400	1200	5400	760	1170	1890	2600	800

Note: In this table, the writer employs brief notations expressing 10 types of shoals, respectively, as shown below:

Shoal with no association	S_a	Shoal baiting near the sea-surface	S_f
Shoal with birds	S_b	Shoal with timber	S_g
Shoal with jumping members	S_c	Shoal with shark	S_h
Shoal with baits	S_d	Shoal with whale	S_i
Shoal swirling near the sea-surface	S_e	Shoal of indistinct type	S_j

The rate of the number of pursing with catch (f) for various behaviours of each species of fish is calculated based on the data of five years and shown in Table 83. Though these values had been calculated dividing into one boat seine fleets and two boats seine fleets, there had been no difference between both types of the fleets. Therefore, this table has been arranged lumping together two types of the fleets.

It is shown from this table that the number of detection of the shoals with birds and with jumping members is frequent on each species of fish, but that of the shoal with no association is relatively few on each species of fish and also that of the shoal with shark and whale is few except for skipjack and the mixed shoal.

According to Kimura[48] on skipjack angling fishery the ratios of detection of the shoal with birds, with no association and with shark to that of total shoals are great and those of the shoal with whale, timber, bait and jumping numbers are small.

Thus, the ranked order of the number of detection of various behaviours of shoals of the purse seine fishery and angling fishery, is differed, this may be due to the difference of the fishing-grounds of the both.

The shoals showing higher average catch per pursing (C) are the shoal with bait, swirling near the sea-surface and baiting near the sea-surface. This fact may mean that these shoals are relatively easy to catch, because they are not actively on their behavioristic character. It is interesting that on angling fishery for skipjack the shoal with bait is very hard to angle, but on the contrary on purse seine fishery the rate of number of pursing with catch of this shoal indicates so large over 50% that this shoal may be easily caught with net.

The number of detection of the shoals with shark, timber and whale is little but the rate of the number of pursing with catch of them is great. Finally, it is found from Table 83 that average of catch per pursing (C) for each species of fish is not related to the rate of the number of pursing with catch (f).

b. Relation between size of the grouping of shoals and rate of the number of pursing with catch

In this study, the size of the grouping of shoals is divided into three classes based on the observation of fishermen's naked eyes; the large, the intermediate and the small groups for each species of fish.

The rate of the number of pursing with catch (f) for each size of the grouping of each species of fish were calculated dividing into one boat and two boats seine fleets as shown in Table 84 from the data which have been arranged through five years of 1953~1957.

It is shown from this table that the rate of the number of pursing with catch (f) of the small group is higher than that of the large group on almost species of fish and two types of the fleets. (Sword-fish was saved from this table as the data is few.) But the values of C (the catch per pursing with catch) of the large group is 1.8~6.3 times as large as that of the small group on each species of fish and two types of the fleets.

Furthermore, following this table, on blue-fin-tuna and young-tuna of the

Table 84. Values of f for the groupings of various species of fish.

I. One boat seine

Species	Blue-fin-tuna				Yellow-fin.tuna				Young-tuna				Skipjack				Mixed species			
	G	I	S	Aver-age	G	I	S	Aver-age	G	I	S	Aver. age	G	I	S	Aver-age	G	I	S	Aver-age
n/N	28/145	16/65	53/196	97/401	21/43	10/24	53/98	84/165	5/26	5/18	22/59	32/107	34/72	22/39	101/172	157/283	13/31	7/11	26/37	46/81
f	0.19	0.25	0.26	0.24	0.49	0.42	0.54	0.51	0.19	0.28	0.37	0.28	0.47	0.56	0.59	0.56	0.41	0.64	0.70	0.59
C	4330	2260	760	2220	2890	2140	890	1540	2000	2370	1170	1500	3080	2660	830	1520	4510	2100	1110	1920

II. Two boats seine

Species	Blue-fin-tuna				Yellow-fin-tuna				Young-tuna				Skipjack				Mixed species			
	G	I	S	Aver-age	G	I	S	Aver-age	G	I	S	Aver-age	G	I	S	Aver-age	G	I	S	Aver-age
n/N	27/85	38/110	53/120	119/315	2/5	4/7	11/14	17/26	3/3	1/7	5/9	9/19	5/5	8/10	20/28	33/43	3/6	7/7	8/8	18/21
f	0.33	0.34	0.44	0.38	0.40	0.57	0.78	0.65	1.00	0.14	0.55	0.47	1.00	0.80	0.71	0.76	0.50	1.00	1.00	0.86
C	7580	3430	1630	3600	3550	1850	430	870	5420	2580	1260	2860	4060	2460	1010	2070	5190	2060	1630	2540

Note: G: Great group, I: Intermediate group, S: Small group.
$f=n/N$;
n: Number of pursing with catch, N: Total numbers of pursing,
C: Average catch per pursing with catch (Kan).

whole groups the average values of (f) is below 38% on two types of the fleets and on yellow-fin-tuna, skipjack and mixed shoal is above 51% on two types of the fleets.

It is seen, at one view, from these results that the latter species of fish is more easy to catch compared with the former. But as the value of C of Blue-fin-tuna which belongs to the former is the greatest among the whole this supposition seems to be not always ture.

The average rate of the number of pursing with catch (f) through the whole species of fish is 42% and this value denotes that to catch tuna* and skipjack is more difficulty than to catch sardine, horse-mackerel and mackerel.

Compared with one boat seine fleets and two boats seine fleets on the value of f, the latter is higher on each species of fish than the former and on the value of C this reference is also the same as the above except yellow-fin-tuna, thus it is seen that two boats seine is more powerful than one boat seine to catch tuna and skipjack.

c. Comparison of the fishing power between one boat and boats seine fleets

The result that two boats seine fleets is more powerful to catch tuna and skipjack than one boat seine fleets had been already obtained in the previous clause. In here, furthermore, the same problem has been pursed in another means of analysis.

Before 1955 there was no data of two boats seine fishery but after 1955 two boats purse seine fleets have appeared to this fishery by the combination of two seiners which had been operating, hitherto, as one boat seiner.

According to Table 85, the values of f of two boats seine fleets is larger then that of one boats seine fleets except Fleet B of one boat seine in 1956. While, almost values of C of two boats seine fleets in each year are larger than that of one boat seine fleets.

Thus, the result obtained from the previous clause that two boats seine is more powerful to catch tuna and skipjack than one boat seine may be also recognized here.

Practically, there hava been a tendency that one boat purse seine fleets in this fishery on the north eastern coast of the Pacific Ocean have been decreased year by year, on the contrary two boats purse seine fleets have been increased as shown Table 6.

§ 2. The Comparison of the Fishing Power among Ten Purse Seine Fleets for Skipjack and Tuna

The comparison of the fishihg power of skipjack and tuna two boats purse seine fleets was performed on the ten fleets based on Ishinomaki in Miyagi Prefecture and it was examined wheter the fishing power of them would has been influenced to the size of nets or the technique of crew.

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* blue-fintuna, young-tuna and yellow-fin-tuna.

Table 85. Comparison of the difference in fishing power between one boat seine and two boats seine.

Year	One boat seine						Two boats seine								
	n/N	f	C (Kan)	n/N	f	C	n/N	f	C	n/N	f	C	n/N	f	C
1955	A (178.5 tons)			B (148.6)			C · D (137.5, 123.0)			E · F (163.5, 123.0)					
	39/94	0.41	1850	33/79	0.40	1900	28/54	0.52	2940	24/48	0.50	1900			
1956				B			C · D			E · F			A · B		
				47/59	0.68	2320	36/84	0.43	3650	45/86	0.52	2210	4/11	0.36	5470
1957	A			B			C · D			E · F			G · H		
	15/37	0.24	2600	22/45	0.49	1820	15/51	0.29	4420	19/40	0.39	2580	30/56	0.53	3200

Note: A, B....H: Name of seiners.

Data

Skipjack and tuna purse seine fleets based on Ishinomaki numbered about 50 in total in 1958 and its numbers hold approximately one third of the whole skipjack and tuna purse seine fleets operating on the north east of the Pacific Ocean.

Each fleet is informed its own fishery office at the base by wireless telephone from the fishing-grounds on the fishing conditions once or twice a day, and each fleet can intercept freely the fishing information of other fleets.

The data used in this study are such fishing informations that the No. 11 Myōjin Maru had collected with a wireless telephone during the period of 1958 from another 52 fleets and from these data and her own data ten fleets for the investigation were selected according to priority of the order of the number of days at sea among the whole 53 fleets. The elements of boats and nets of the ten fleets selected were investigated by the author's hearing-research from fishermen (Table 86). In this study, "tuna" denotes a kind of tuna including blue-fin-tuna, young-tuna, yellow-fin-tuna and sword-fish.

Table 86. Tonnage of seiner, size of net and number of crew of each fleet.

Name of fleet	A	B	C	D	E	F	G	H	I	J
Tonnage of seiner (ton)	85.0	80.0	86.0	84.0	85.0	83.0	80.0	80.0	85.0	83.0
Length of float line (m)	1380	1500	1650	—	—	1470	—	1570	1650	—
Depth of net (m)	285	280	255	—	—	255	—	240	270	—
Number of crew	78	84	76	80	83	84	82	85	75	80

Results

As tuna and skipjack are migrating with high speed the fleets have been in pursuit of them place to place and day to day. Therefore, the operation areas of the ten fleets selected are not always the same (Fig. 35 shows, as one example, the case of July 29th) but analysis of the data indicates that several fleets of the ten fleets are always operating at closely areas each other in the same day.

Assuming that the area surrounding with one degree longitude and latitude is "the same fishing-ground" (Fig. 35, the case of July 19th) we may be apply the method of measurement of the fishing power (1) to the daily catch of the fleets which had been operating "the same fishing-ground".

The relative values of the catch of each fleet that were calculated by the above method and the rank of them from 1 to 10 are shown respectively in Table 87. This table also shows that the rate of the number of pursing with catch (f), the catch per pursing with catch (C) and average catch of (C) joined together skipjack and tuna and the ranks of the average catch from 1 to 10 similar to the ranks of the relative values.

From this table it is shown that the value of f of skipjack is superior to that of tuna on each fleet, therefore, it is found that to catch skipjack is more easy than tuna, this fact had been obtained already in the previous paragraph.

Compared with the ranks of the relative values of the catch and the ranks of the average catch per pursing with catch of each fleet they are in relatively corresponding relation.

Judging from the ranks of the above two items it may be possible to decide that Fleets C, H and I are superior and Fleets A, B, E and F are inferior on the fishing power. According to Table 86 Fleets A and F belonging to the superiors have smaller size nets than Fleets H and I belonging to the inferiors, but such difference of nets is too small, so that, it may be almost not related to the fishing power.

Compared with the superior and the inferior fleets on the values of C in each month (Table 87) there is no great difference for skipjack, but there is a definite difference for tuna, the values of C of the superiors are several times as large as those of the inferiors.

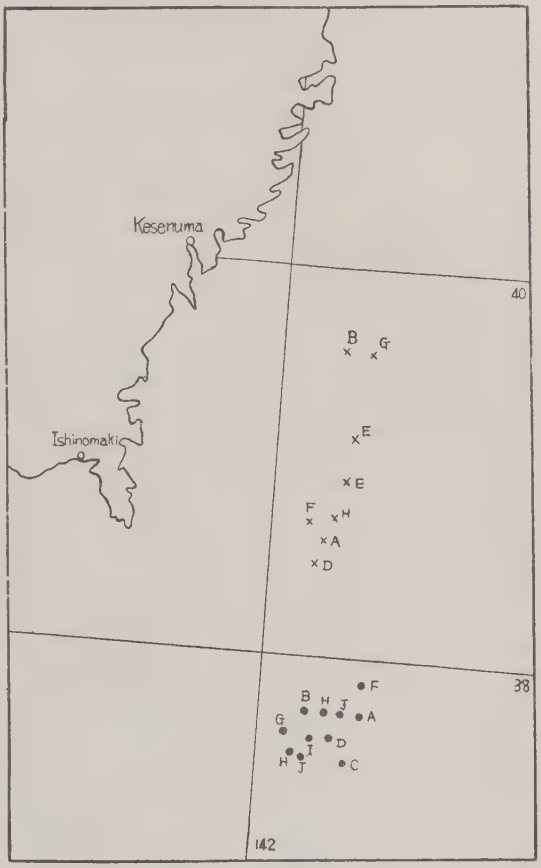

Fig. 35. One example of fishing place of ten fleets in 1958.
Note: ●: July 19
×: July 29
Alphabet: Name of fleets

In skipjack and tuna purse seine major fishing game is tuna and the minnor is skipjack as shown with the values of f in Table 87.

Therefore, the difference of the fishing power between the superior and inferior fleets may be mainly caused by the amount of tuna catch and furthermore this may be attributed to the difference of the technique of crew on seiner, because to catch tuna is more difficult than to do skipjack and needs a more advance technique of crew for swimming speed of tuna is further higher than that of skipjack and it's character is easily frightened by a net than skipjack.

Consequently, it may be said that the difference of the fishing power of skipjack and tuna purse seine fleets is greatly caused by the technique of crew.

Table 87. Rate of the number of pursing with catch (f), catch (C) and relative value of the catch.

Month	Species	A		B		C		D		E		F		G		H		I		J	
		f	C (Kan)	f	C	f	C	f	C	f	C	f	C	f	C	f	C	f	C	f	C
June	Skipjack (S)	2/4	7,200	1/1	1,000	4/5	2,000	1/5	300	1/5	1,200	2/3	600	3/4	2,000	2/5	800	1/7	5,000	1/7	1,000
	Tuna (T)	3/11	3,900	4/10	10,300	5/18	12,000	5/18	17,300	2/10	1,100	3/11	6,000	5/13	7,800	0/11	0	3/15	13,900	1/12	6,400
July	S	0/1	0	2/4	4,200	6/7	18,000	3/4	1,900	3/3	1,400	2/2	11,000	3/3	5,200	5/5	11,800	2/3	5,000	2/3	1,200
	T	2/16	1,000	2/15	2,800	4/15	14,800	2/12	2,400	4/15	7,000	3/20	1,300	3/12	3,600	0/11	0	3/22	7,000	2/20	5,300
Aug.	S	7/9	15,800	4/11	10,500	8/11	27,300	10/19	31,700	5/14	7,100	5/7	16,500	6/11	28,800	6/15	18,500	5/10	4,600	1/5	5,000
	T	1/12	1,000	3/9	3,300	3/10	900	2/8	400	1/12	400	4/10	5,600	2/6	2,500	1/6	700	2/7	1,000	4/10	12,700
Sep.	S	7/7	20,200	5/8	8,300	2/3	1,600	5/6	5,600	2/4	11,000	3/4	5,500	6/6	9,200	4/4	10,300	6/8	16,300	1/2	200
	T	4/8	1,000	3/16	1,800	4/14	26,000	5/13	7,200	4/13	1,400	10/21	7,600	4/10	4,400	3/11	1,800	4/12	1,400	5/10	6,600
Oct.	S	—	—	—	—	0/1	0	0/1	0	—	—	—	—	—	—	—	—	—	—	—	—
	T	1/6	3,000	1/8	100	2/10	5,900	1/9	400	0/4	0	2/7	4,500	2/10	3,500	2/3	47,200	1/5	9,000	2/8	12,200
Nov.	S	—	—	—	—	—	—	0/1	0	—	—	—	—	—	—	—	—	0/1	0	—	—
	T	6/7	4,000	0/9	0	1/4	3,500	1/6	3,000	0/9	0	0/8	0	0/7	0	1/7	200	2/8	13,200	2/9	2,100
Average (C)	S	0.79	2,640	0.52	1,910	0.77	2,440	0.53	2,800	0.38	1,900	0.38	3,300	0.75	2,500	0.58	2,460	0.48	2,380	0.30	1,480
	T	0.20	1,160	0.19	1,400	0.27	3,200	0.32	3,260	0.17	900	0.28	1,150	0.28	1,300	0.14	7,100	0.21	3,200	0.23	2,830
Average catch per pursing with catch		1,730		1,510		2,880		2,060		1,390		1,710		1,970		3,800		2,570		2,510	
Ranks of the above		7		9		2		5		10		8		6		1		3		4	
Relative value of the catch		0.70		0.75		1.36		1.06		0.85		0.80		0.95		1,51		1.08		0.94	
Ranks of the above		10		9		2		4		7		8		5		1		3		6	

Note; f: Namber of pursing with catch/total number of pursing
C: Catch per pursing with catch

IX. Summary

The purse seine fishery, which is typical Round Haul Net fishery, occupies a very important position in the coastal and off-shore fisheries in Japan.

The purse seines are mainly used to catch anchovy, sardine, round-herring (the three species are called "sardines", here) horse-mackerel, mackerel, skipjack and tuna, and more than half the yearly catch of sardines, which are the most important species for Japanese fisheries because of these wide distribution, is caught by them.

After the period of 1936 when the maximum level of production was reached, the catch of sardine has decreased rapidly, and after the World War II, during the periods of 1950 to 1954, by the modernization of boats and the utilization of new installations such as fish finders and wireless telephones the catch of sardine has increased and at that time the sardine resource appeared to be recovering temporally, but since then the catch year to year is rising very little. This fact makes us feel some anxiety about the sardine resource.

Similar phonomenon has appeared in the catches of anchovy, but the data are more optimistic compared with the case of sardine.

Thus, the sardine purse seine fleets in the East China Sea have been changing to horse-mackerel and mackerel seiners and the anchovy purse seine fleets in the eastern sea area of Japan plan to change to skipjack and tuna or other fisheries. And consequently, an antagonisum has resulted which should be solved rapidly between purse seine fisheries and other fisheries and with in the purse seine fisheries themselves.

Therefore, the problems with which the purse seine fisheries are confronted at present are not only to try to improve fishing gear but also to try to manage the operation of fishing boats for the orderly fisheries to preserve and develop the marine products resources.

In this study, to obtain the practical knowledge related to these problems the following three items have been pursed.

1) Problem on the measurement of the fishing power.
2) Problem on the control and the management of fisheries.
3) Problem on the judgement of the increase and decrease of fishing resources.

On Problem 1), it has been investigated that in what manner the fishing power of the purse seine fleet is influenced by the elements such as the tonnage of boats, the size of nets, presence or absence of fish finders and wireless telephones, the technique of crew, and other factors, and among the above what element governed definitely the fishing power, and furthermore when the improvement of fishing gears and methods is made, whether or not it brings about the desired result.

On Problem 2), when over two kinds of fisheries have been carried out in the same fishing-ground, mutual relation of each fishery, such as whether or not and in what manner the one interrupts the others, and the comparison of the fishing power of them is examined to obtain the fundemental data concerning the control and management of fisheries.

On Problem 3), as the justifiable judgement on the increase and decrease of fishing resources must be based on the correct information on the fishing effort and the fishing effort itself must be investigated from the point of view of it's quantity and quality, the variation of the fishing effort per unit year to year is counted by the method of the measurement of fishing power and it will be very useful to solve the question concerning fishing resources.

In this studies, the following methods were applied to count the fishing power.

1) The method of measurement of the fishing power when the fleets are fishing in the same place and time.
2) The method of measurement of the fishing power when the fleets are fishing in different place and time.
3) The method of estimation of the fishing-rate from the variation of catch per unit time.
4) The method of estimation of the fishing-rate from the variation of catch per unit time.

The brief results obtained from this studies will be described dividing into the three items mentioned above as follows.

1) On anchovy purse seine fishery it is found that the difference of the fishing power among each fleet is caused by the tonnage of seiners, the size of nets, the kinds of material of nets or the technique of crew, and among these elements the tonnage of seiners and the size of nets influence most powerful to the fishing power, and generally the tonnage of seiners is proportional to the size of net.

In the case of the capture of skipjack and tuna, as they are swimming with high speed and furthermore they are liable to escape from the encircling net a higer technique of the crew is required than the case of sardines.

In the purse seine fishery for sardine, horse-mackerel and mackerel in the East China Sea as the catch composition-rate for the species of fish caught differes between smaller tonnage fleets and larger tonnage fleets, smaller tonnage fleets with shorter nets in depth are catching mainly sardine which is swimming in shallower layers and larger tonnage fleets with longer nets in depth are catching mainly horse-mackerel and mackerel which are swimming in deeper layers than sardine, the former gains higher relative fishing power on sardine but the latter gains higher relative fishing power on both horse-mackerel and mackerel.

As the result of the comparison of the fishing power between one boat and two boats purse seine fleets for horse-mackerel and mackerel it is found that two boats purse seine seems to be more suitable to catch them than one boat purse seine. But as two boats purse seine fleets liable to be governed by the weather and sea condition, the number of days at sea of two boats purse seine fleets is less compared with that of one boat purse seine fleets, and then in the comparison of the catch per month or year the former is less than the latter. In skipjack and tuna purse seine fishery, too, the fishing power of two boats purse seine fleets is superior to that of one boat purse seine fleets, but there is

no difference in the number of days at sea between one boat and two boats purse seine fleets.

The condition of fishing harbour influences on the fishing power of purse seine fleets, too. For example, at Katagai on the east coast of Chiba Prefecture there is no fishing harbour because of the shalloness of the adjacent water up to a great distance away from the shore, on the contrary, at Ōhara which is situated near Katagai, there is a fishing harbour and it is recognized that the fishing power of the Ōhara fleets is superior to that of the Katagai fleets. Similar reference is found between Chōsei and Togawa. As Chōshi has a better facility of fishing harbour than that of Togawa, the Chōshi fleets have, of course, a higher fishing power than the Togawa fleets.

2) As the problem on the control and management of fisheries follow-the ing studies were performed from the point of view of the fishing power, that is, the relation between purse seines and beach seines in Kuzūkuri-hama, Chiba Prefecture, and between coastal two boat purse seines and lampara nets (both kinds of net-boats are less 5 tons) in Nagasaki Prefecture and furthermore, the relation between purse seine fleets based on Yamaguchi, Saga, Fukuoka, and Kumamoto Prefectures faced to the East China Sea and Nagasaki Prefecture purse seine fleets.

In the comparison between purse seines and beach seines in Kuzyūkuri-hama it is found that the fishing power of purse seine is about 10 times as large as that of beach seines, and the decrease of the catch of beach seine in recent years may be mainly caused by the powerful pressure of the purse seine fleets.

In the case of coastal two boat seines and lampara nets, in spite of two kinds of nets operating in the same fishing-ground, as the one never interrupts the other and moreover the fishing power of them is almost the same, there may be no antagonisum on the fishing operation between them.

As one boat purse seine fleets in Nagasaki Prefecture are numerous and often go out off other prefectures there is always antagonisum between the Nagasaki Prefecture fleets and other prefectures fleets or between the former and other coastal fisheries such as gill net or others. Thus, the fishing antagonisum in these areas becomes a very considerable problem on the fishing management. As the rosult of the comparison of the fishing power between the Nagasaki Prefecture fleets and other prefectures fleets, it is indicated that the fishing power of Nagasaki Prefecture fleets is a little superior to that of other prefectures, Yamaguchi, Saga, Kumamoto, fleets.

3) After the World War II the fishing power of purse seine fleets rose remarkably owing to the equipping of fish finders and wireless telephones, the use of synthetic fiber nets or the shortening of mesh size. But, this fact, namely, the increasing of the fishing power suggests a considerable problem on the maintenance of fishing resources.

In the consequence of the investigation on the purse seine fleets in Chiba Prefecture, it is found that the use of fish finders makes the finding of shoals under the sea-surface easy and consequently it makes the fishing power of the purse seine fleets several times as large as the before.

More the utilize of wireless telephones makes the fleets concentrates at

good fishing-grounds by the connection with each other and putting together the use of fish finders it has brought about the rising of the fishing power of purse seine fleets.

Furthermore, it is recognized that the use of synthetic fiber nets bring about the increase of fishing effort in quantity and the shortening of mesh size of nets makes the catch of smaller size fish increase.

But during the periods of these investigations from 1950 to 1955, there had been no tendency to increase the amount of shoals coming to the fishing-grounds and the increase of the catch had been only maintained by the intensification of fishery, namely, the rise of fishing power or the increase of fishing effort in quantity.

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STUDY ON FISHING ABILITY OF TRAWL FISHERIES ON THE EAST CHINA AND THE YELLOW SEAS

Kenji KANDA

I. Introduction

Under what conditions can trawl fishery be operated with best results?

The catch actually attained is of course a function of a number of variables such as the time of year, geographic situation of fishing ground, type of fishing vessel, species of fish caught, etc., under simultaneous specialization of which the actual fishery was carried out. As a matter of fact, however, they are more or less intimately correlated with each other. Thus, it is few and far between that all existing vessels both for otter trawl and pair trawl are simultaneously operated on one and the same fishing ground. In other words, daily operations of trawl fishery may be said to be practised by different types of vessels and in different fishing grounds throughout a whole year, in said circumstances, therefore, the actual catch attained by each particular vessel and reported in authentic publications being inevitably far from such data directly available for judging the efficiencies with which past daily or monthly fisheries were performed.

It may be considered, on the other hand, that every one of said variables, for instance, the type of fishing vessel, has its own "fishing ability," viz., the ideal relative catch to be attained under the constancy of all variables except the particular one under consideration, while the fishing ability of a particular variable, in turn, can vary according to this variable itself.

"Whether a round of trawling was carried out really at a high efficiency?" or, speaking from a more general standpoint, "by what way of operation can trawl fishery be rewarded with a best catch?" is a question to be answered indeed first on a correct knowledge of "fishing ability."

It follows from the actual circumstances stated above that the appreciation of fishing ability for every type of trawler, for instance, demands such preliminary modification of the published crude data of catches as to shut out the defects of incidental conditions under which each vessel did engage in fishing. The same will be the case also with variables other than the type of vessel. In the present work in which recent trawl data from the East China and the Yellow Seas were taken up for discussion, the data were, therefore, first submitted to recalculation as explained elsewhere to meet the idea of fishing ability.

II. Outline of Trawl Fishery in the East China and the Yellow Seas

The fishing ground referred to in the present paper extends from the East China Sea to the Yellow Sea and has long made an object of two types of trawl fisheries, viz., otter trawl and pair trawl.

According to the data of 1953 for the fishery concerned, 58 fishing vessels

each 332 tons on the average engaged in otter trawl and 783 fishing vessels each of 73.2 tons on the average in pair trawl, gross tonnage of them totaling 76,568 tons.

The catch attained in the year of 1953 by the so-called domestic marine fisheries of Japan has been reported as about 4,200–4,500 thousand tons. The total catch by trawl fishery in the same year was 275 thousand tons, of which 33 thousand tons and 242 thousand tons were attained by the otter trawl and the pair trawl fisheries, respectively, corresponding accordingly to about 6.4% of the total catch attained by domestic marine fisheries.

Fishing vessels for the otter trawl are legalized to be made of steel, to be larger than 200 tons in gross tonnage and further to be capable of developing a speed higher than 11 miles per hour. Though gross tonnage of fishing vessels for the pair trawl has been stipulated by New Fisheries Law to be above 50 tons, those smaller than 50 tons are still licensed to engage in the transitory medium pair trawl, insofar as an area between Long. 130°E and Long. 128° 30′E is concerned.

In Japan, base ports for the otter trawl are Shimonoseki, Tobata and Nagasaki, while those for the pair trawl are Shimonoseki, Hagi, Tobata, Imari, Karatsu, Nagasaki, Saseho and Kumamoto.

The trawl fisheries is peculiar not only in that it is operated over an area of great broadness and quite remote from the base but also in its making a means for realizing a planned production of fish. For these reasons, the fishing vessels concerned are truly large-sized in contrast with those for coastal bull trawl and operated on a large scale. Thus, the otter trawl in particular has been monopolized only by six big companies, viz., Nihon-Suisan Co., Taiyo-Gyogyo Co., Kyokuyo-Hogei Co., Nanpo-Gyogyo Co., Nichiro-Gyogyo Co. and Kawanami-Gyogyo Co., while the pair trawl is operated chiefly by Nihon-Suisan Co., Taiyo-Gyogyo Co., Nichiro-Gyogyo Co., Nitto-Gyogyo Co., Tokushima-Suisan Co. and Kyokuyo-Hogei Co. The enterprisers concerned are numerated to 104 throughout all aforementioned bases. As these enterprisers generally engross each a lot of fishing vessels, their number is small as compared with the number of fishing vessels.

III. Numerical Formulation of Fishing Ability

Since almost all the data of catch in trawl fisheries have been reported for different fishing ground sections subjected to the operation of incidental individuals of fishing vessel in different months of year, it is necessary in evaluating the fishing ability of trawling in the sense mentioned in I to begin with the evaluation of the average catch among different sections in comparison with which a catch actually attained is to be appraised. On the other hand, however, since different sections of a fishing ground are the respective workshops of different vessels in different times of the year, the catches attained there turn out generally scattered around the average catch evaluated. Thus, expressing the average catch in the ith month of the year as S_i in the equation

$$S_i=\frac{1}{m}\sum_j C_{i,j} \qquad (1)$$

where $C_{i,j}$ means the average catch-per-unite-effort which is calculated from the total catch attained by all the vessels actually engaged in the ith month in the jth section and m the total number of sections constituting a whole fishing ground in the ith month, the average catch-per-unite-effort from the jth section in the ith month, $C_{i,j}$, may be represented as $g_{i,j} \cdot S_i$ where $g_{i,j}$ means a factor which varies from month to month chiefly owing to artificialities such as types of the vessels engaged and the time of year in which the jth fishing ground section was submitted to trawling.

Now, if a constant factor g_j is employed instead of $g_{i,j}$ to get out of monthly effects of artificialities on the catch in the jth section, the product $g_j \cdot S_i$ will obviously be not equal to $C_{i,j}$. However, by chooing the factor g_j so as to satisfy the following expression of least square:

$$\frac{\partial}{\partial g_j} \sum_i (C_{i,j} - g_j \cdot S_i)^2 = 0 ,$$

or in other words of the solution of the above equation, namely

$$g_j = \frac{\sum_i C_{i,j} S_i}{\sum_i S_i^2} \tag{2}$$

g_j may be used for representing the ideal average catch-per-unite-effort in the jth fishing ground section as $g_j S_i$ independent of types of the vessels actually engaged and the month in which said section was submitted to trawling, and that without leading to a serious error. The factor thus defined will be called in this paper the coefficient of productivity of the jth fishing ground section, a constant value of g_i being available for a whole year.

Next, calling the catch attainments of individual vessels to account, the actual production brought in the ith month from the jth fishing ground section by a particular vessel may be represented as ag_jS_i where a means a constant factor particular to Vessel A. If, on the other hand, the total catches averaged to a trawling of unit round by A is represented, analogously to the case of $C_{i,j}$, as $A_{i,j}$, the most probable value of the factor a may be given as the solution of the equation of least square

$$\frac{\partial}{\partial a} \sum_i \sum_j (A_{i,j} - a g_j S_i)^2 = 0$$

and hence

$$a = \frac{\sum_i \sum_j A_{i,j} g_j S_i}{\sum_i \sum_j g_j^2 S_i^2} \tag{3}$$

insofar as the actual production is considered in reference to that attained through a trawling of unit round. The factor a will be called the index of fishing ability of Vessel A.

Insofar as trawlings in definite conditions of fishing ground are concerned, or when g_j does not greatly vary among different fishing ground sections, a may be given as

$$a = \frac{\sum_i A_i S_i}{\sum_i S_i^2} \tag{4}$$

and further when S_i does not greatly vary among different months, a may be given approximately as

$$a=\frac{\sum_i A_i}{\sum_i S_i} \tag{5}$$

In the following, the reason why "fishing ability" has to be appraised according to the above formulation will be explained with reference to actual data of catches by trawling.

IV. Fishing Ability of Otter Trawl Fishery

IV, 1. Fishing ability appraised for a particular base port and a particular type of fishing vessel.

According to the official publication "Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas" from which the data for the years of 1951-1953 were extracted as the materials for the present work, whole trawl vessels concerned are divided according to their types into two main classes, viz., those of Diesel engine type (D) and of steam engine type (S). In respect of gross tonnage, on the other hand, they are divided into four classes, viz., the vessels of below 250 tons (0), of 250-350 tons (I), of 350-500 tons (II) and those of above 500 tons (III). The number of registered trawl vessels present in December of 1951, 1952 and 1953 are uniformly 58; it is reproduced in Table 1 not only by fishing base but also by type and gross tonnage.

Table 1. Yearly numbers of registered otter trawlers.

Base port	Shimonoseki					Tobata					Nagasaki		Total
Type of vessel	DI	DII	DIII	SI	SII	DI	DIII	SO	SI	SII	DI	SI	
1951	14	—	5	10	2	3	4	4	5	3	2	6	58
1952	14	—	5	10	2	3	4	4	9	4	2	1	58
1953	14	5	—	10	2	3	4	4	9	4	2	1	58

In the present work, putting the account on such trawlers as had been operated at least six months a year and assignable with an yearly ratio of operation* of above 0.400, comparative values of fishing ability were calculated for different trawl-bases and types of vessel.

As readily calculated from the values in Tables 2, 3 and 4, monthly number of tripdays averaged to a boat belonging to a particular class and a particular trawl-base is estimated in reference to that averaged to one vessel irrespective

* Representing the number of registered trawlers present in the ith month as N and that of actually operated as n_i, the yearly ratio of trawl operation is given as

$$\eta=\frac{\sum_{i=1}^{12} n_i}{\sum_{i=1}^{12} N_i}.$$

Table 2. Fishing ability by base port and type of vessel for otter trawlers in 1951.

Base port	Shimonoseki				Tobata					Nagasaki	Mean
Type of vessel	DI	DIII	SI	SII	DI	DIII	SO	SI	SII	SI	
Yearly ratio of operation	0.61	0.70	0.63	0.61	0.78	0.46	0.63	0.90	0.82	0.88	0.68
Average number of fishing days per month	24.9	28.2	23.8	18.1	23.3	23.7	23.2	22.2	24.6	22.2	23.8
Average number of draught per month	114	125	112	78	91	88	87	85	96	76	99
Average operation time per draught in hours	3.32	3.29	3.19	3.54	3.88	3.79	3.82	3.77	3.78	3.94	3.51
Coefficient of fishing ability	0.85	0.84	0.77	1.12	1.10	1.08	1.07	1.20	1.27	1.34	1.00

Table 3. Fishing ability by base port and type of vessel for otter trawlers in 1952.

Base port	Shimonoseki				Tobata				Nagasaki	Mean
Type of vessel	DI	DIII	SI	SII	DI	SO	SI	SII	SI	
Yearly ratio of operation	0.64	0.55	0.52	0.92	0.69	0.81	0.82	0.84	0.62	0.66
Average number of fishing days per month	25.6	25.9	27.1	25.2	24.8	24.8	23.9	24.5	23.8	25.1
Average number of draught per month	116	121	120	103	97	88	85	88	83	103
Average operation time per draught in hours	3.57	3.72	3.60	3.34	3.69	3.68	3.83	3.82	3.88	3.66
Coefficient of fishing ability	0.92	0.80	0.95	1.13	0.96	1.11	1.33	1.58	0.86	1.00

Table 4. Fishing ability by base port and type of vessel for otter trawlers in 1953.

Base port	Shimonoseki			Tobata				Mean
Type of vessel	DI	SI	SII	DI	SO	SI	SII	
Yearly ratio of operation	0.55	0.59	0.92	0.72	0.88	0.93	0.67	0.70
Average number of fishing days per month	26.0	27.5	26.1	27.0	25.3	25.9	25.8	26.2
Average number of draught per month	115	130	105	115	97	97	102	110
Average operation time per draught in hours	3.62	3.65	3.41	3.38	3.42	3.70	3.49	3.57
Coefficient of fishing ability	0.92	0.95	0.93	0.85	0.95	1.13	1.38	1.00

of trawl-base and class of vessel to be 0.76–1.19, 0.95–1.08 and 0.97–1.05 for 1951, 1952 and 1953, respectively. On the other hand, monthly number of repeat of trawl averaged to the doing of one vessel falls between 0.77 to 1.26 in 1951 in reference to the average monthly number of repeat of trawl rounds for each boat, the corresponding relative values amounting to 0.81–1.71 and 0.89–1.18 for 1952 and 1953, respectively. As reflected in the yearly fluctuation in these values, the actual circumstances in trawl fishery as already mentioned in I, makes it improper for standardizing the catch assignable to unit round trawling operation to employ crude data for the catch attained in effect by an actual round of trip of a particular trawler or those for total catches each built up by indefinite individuals of trawler which were casually operated in a particular month. Mere arithmetic mean of the sum of these values as well may be looked upon as rather meaningless to be employed. For this reason, the values for index of fishing ability recorded in Tables 2, 3 and 4 have been calculated by means of Equation (5).

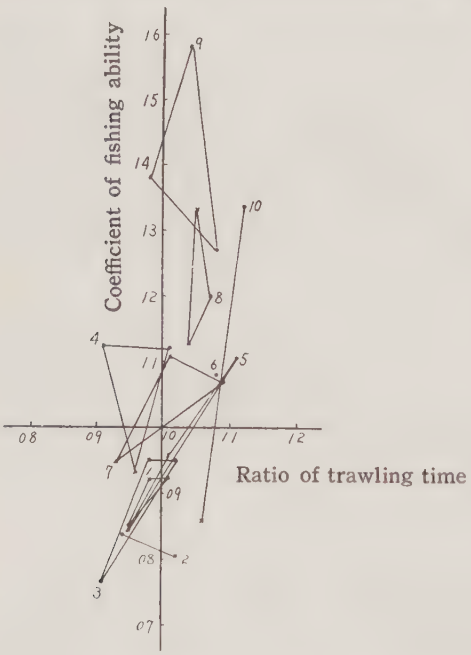

Fig. 1. Relation between time of draught and coefficient of fishing ability of otter trawlers, where ●, ×, ▲ stand for the data for 1951, '52 '53, respectively, and the numeral show the type and base port of vessel, as given below.

Type of vessel \ Base port	Shimonoseki	Tobata	Nagasaki
DI	1	5	—
DIII	2	6	—
SO	—	7	—
SI	3	8	10
SII	4	9	—

As readily deduced from the values in these tables, average time taken in unit round of trawling by a particular type of vessel, when estimated as its ratio to the time of trawling averaged to a vessel irrespective of her peculiarity, falls in the range of 0.91–1.12 for 1951, while the corresponding values fall in ranges of 0.91–1.06 and 0.93–1.04 for 1952 and 1953, respectively. In Fig. 1 indices of fishing ability for various particular trawlers are plotted against the values of aforementioned ratio or relative time for unit round of trawling. Generally speaking, the longer the trawling time, the greater catch is attained in show. However, as a matter to be noticed, this apparent situation must not be put to a hasty interpretation. The time taken in unit round of trawling is usually about 3.5–

4.0 hours. Sometimes, however, a trawling round can be stopped half-way, if not from some troubles on board, owing to an unexpected big catch. As a matter of far greater importance, the violent increase of index of fishing ability with increasing trawling time, which is apparent in Fig. 1, suggests an unreasonable situation of that, at an early stage of a round, trawlings have to be operated for a long while in vain. In this point of view, Fig. 1 is rather to be taken as suggesting that trawling time will never make a prime factor that controls the index of fishing ability.

According to Fig. 1, index of fishing ability is particularly bad with Shimonoseki trawlers DI (1), DIII (2) and SI (3) and particularly good with Tobata trawlers SI (8) and SII (9). As for trawlers different in fishing base but uniform in type, DI, DIII, SI and SII of Tobata show higher values of index of fishing ability as compared with those of Shimonoseki (see in the figure the combinations 1–5, 2–6, 3–8 and 4–9). This means that fishing base of trawlboat is possible to have a great influence on the index of fishing ability.

IV, 2. Fishing ability by trawl-base, type of vessel and kind of catch.

IV, 2, a. The fishing ability in the aspect of fishing season alone.

Fishes caught by trawling in the East China and the Yellow Seas are of great variety in species. It is therefore easily supposed that aforementioned large difference between the catches may be traced to mutual diversity in the species of fish caught by a definite type of trawlers belonging to different bases. In this point of view, fishing ability of trawling is now to be investigated in separate aspects of fish species, trawl-base and type of vessel, referring to the data for 1953.*

When yearly data for catch by trawling, for example, those in 1953 are classified by species of fish, it will be disclosed that the share of a particular kind of fish in the total catch inclusive of all species of caught fishes varies substantially according to the secies of the fish. Thus, as for the catch in 1953, hairtail, *Trichiurus lepturus* Linné, and yellow croaker, *Pseudosciaena manchurica* (J. & T.), were caught in such exceptional large quantities that their sum alone makes 57.1% of the total catch. Moreover, said share of a particular fish changes also in accordance with the time of the year, as obvious from seasonal fluctuation of the

* When 40 individuals of trawler actually operated in said year are called to account, while they are classified into 0, I, II and III according to gross tonnage and into D and S according to main engine they carry, trawlers belonging to class I (250–350) may conveniently be classified into two groups, the one falling in a range of 270–300 tons and the other in 310–350 tons. Representing the trawlers of the former group as IA and those of the later as IB, marked differences in the tonnage averaged to an individual boat are found to prevail as shown in Table 5 between different trawl-bases.

In this reference entitled "Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas" the name of month is recorded in the arrangement according to the month when trawlers returned to their bases. In this reference also the total catch for each month is recorded under the month in which the trawlers came back to their bases. As the average interval of a round of trip is 23–26 days for every boat, the month under the name of which the catches are totaled is not coincident with the month in which the actual fishing was carried out.

Table 5. Number of otter trawlers actually operated and average tonnage and engine horse power by base port and type of vessel in 1953.

Base port	Shimonoseki				Tobata				
Type of vessel	DIA	DIB	SIA	SII	DIA	SO	SIA	SIB	SII
Tonnage class	250 ~300	300 ~350	250 ~300	350 ~500	250 ~300	~250	250 ~300	300 ~350	350 ~500
Number of otter trawlers actually operated	5	7	7	2	3	4	5	4	3
Average tonnage	274.3	342.5	276.1	372.0	285.4	231.3	274.2	331.1	362.2
Average engine horse power	504	520	464	825	523	553	480	573	800

catch per draught of a particular kind of fish. Under these circumstances, estimation of the fishing ability by species of fish should rationally be carried out with resort to E quation 4, $a=\sum_i A_i S_i / \sum_i S_i^2$.

From the monthly average catches per draught calculated by referring to aforementioned report the indices of fishing ability by kind of fish as well as by type of boat and further by trawl-base are estimated for 1953 as shown in Table 6.

Comparing 250–300 tons Diesel engine trawlers, D IA, with 250–300 tons steam engine trawles, S IA in reference to this table, indices of fishing ability of these two types of boat are found for the greater part of the listed fishes to be in the ratio of about 10 to 8 except those of Shimonoseki vessels for snapper, *Taius tumifrons* (T. & S.), gurnard, *Chelidonichthys kumu* (Lesson et Garnot), lizard fish, *Saurida tumbil* (Bloch), hairtail, searobin, *Lepidotrigla microptera* Günther, cuttle fish, prawn and lobster and those of Tobata vessels for large croaker, *Argyrosomus japonica* (T. & S.), hairtail, flat head, *Ptatycephalus indicus* (Linné), prawn and lobster. Examining this situation by preparing a graphical representation as Fig. 2, it seems rather natural to consider said exceptional indices of fishing ability for several kinds of catches to be likely a reflection of that intentional choices of fishing ground were occasionally practised.

Further, when indices of fishing ability of Shimonoseki base and Tobata are compared with each other by the help of the data in this table, it is noticed as seen from Fig. 3 that, insofar as 250–300 tons Diesel engine vessels (DIA), 250–300 tons steam engine vessels (SIA) and 350 500 tons steam engine vessels (SII) are concerned, the indices of these two fishing vessels are in the ratio of about 8:10 for a great portion of the fishes recorded in the table. However, there are seen in the figure also some exceptional cases such as those exemplified by snapper, crimson sea bream, *Evynnis japonica* Tanaka, long tailed snapper, *Nemipterus virgatus* (Houttuyn), large croaker, hairtail, sea robin and cuttle fish caught by DIA-type trawlers, snapper, crimson sea bream, gurnard, large croaker, prawn and lobster caught by SIA-type trawlers and hairtial, flounder, sea robin, prawn and lobster caught by SII-type trawlers. Taking into account the possibility of that different fishing grounds may be different also in the distribution

Table 6. Coefficient of fishing ability by base port, type of vessel and species of fish for otter trawlers in 1953.

Species of fish \ Base port / Type of vessel	Shimonoseki				Tobata				
	DIA	DIB	SIA	SII	DIA	SO	SIA	SIB	SII
1. Porgy, *Chrysophrys major* (T. & S.)	1.17	1.68	0.33	0.95	2.15	0.22	0.91	0.56	0.89
2. Snapper, *Taius tumifrons* (T. & S.)	0	0.94	0.18	1.02	1.22	0.62	1.94	1.49	1.48
3. Blanquillo, *Branchiostegus* sp.	0.39	0.49	1.19	0.36	0.84	1.49	1.20	2.01	0.94
4. Crimson seabream, *Evynnis japonica* TANAKA	0.16	3.75	0.08	0.17	0.92	0.83	0.39	0.35	0.44
5. Long tailed snapper, *Nemipterus virgatus* (HOUTTUYN)	0.33	2.14	0.28	0.55	1.85	0.89	1.17	0.81	1.10
6. Gurnard, *Chelidonichthys kumu* (LESSON et GARNOT)	1.08	0.73	0.04	0.74	2.95	0.55	0.93	1.40	1.73
7. Croaker, *Miichthys imbricatus* (MATSUBARA)	1.44	0.99	0.90	1.08	1.11	0.72	1.16	0.51	0.77
8. Large croaker, *Argyrosomus japonica* (T. & S.)	0.38	2.38	0.04	0.74	4.77	0.56	0.57	0.18	0.42
9. Lizard fish, *Saurida tumbil* (BLOCH)	0.14	0.45	0.82	0.65	0.66	1.35	1.10	1.50	1.77
10. White croaker, *Argyrosomus argentatus* (HOUTTUYN)	1.02	1.13	0.80	1.11	1.36	0.74	1.07	0.92	0.77
11. Yellow croaker, *Pseudosciaena manchurica* (J. & T.)	1.11	1.40	0.60	1.30	1.37	0.75	0.83	0.93	1.16
12. Black croaker, *Argyrosomus nibe* (J. & T.)	1.35	1.86	0.60	0.99	1.39	0.87	1.06	0.86	0.83
13. Hairtail, *Trichiurus lepturus* LINNÉ	0.46	0.21	1.28	0.62	0.17	1.44	0.85	2.24	2.18
14. Sharp-toothed eel, *Muraenesox cinereus* (FORSKAL)	1.35	1.51	0.58	1.04	1.10	1.17	1.08	0.82	0.96
15. Flounder, *Paralichthys olivaceus* (T. & S.)	0.98	2.78	0.27	1.43	1.11	0.13	0.92	0.50	0.36
16. Turbot, *Pleuronectidae*	0.85	0.89	1.08	0.73	0.99	0.83	1.02	1.00	1.13
17. Shark, *Lamnida*	1.53	0.61	0.93	0.78	1.18	0.78	0.44	0.30	1.22
18. Sea robin, *Lepidotrigla microptera* GÜNTHER	1.02	4.42	0.02	1.85	0.009	0.02	0.003	0.002	0.10
19. Flat head, *Ptatycephalus indicus* (LINNÉ)	0.70	0.77	0.86	0.60	0.37	1.14	1.57	1.26	0.96
20. Butter fish, *Psenopsis anomala* (T. & S.)	1.34	0.97	0.89	0.82	1.15	0.91	1.07	1.44	1.21
21. Ray, *Rajida*	1.42	1.43	0.82	1.29	1.73	0.63	0.94	0.64	0.81
22. Cuttlefish	0.23	0.70	1.30	1.30	1.23	0.67	0.70	1.33	1.21
23. Prawn and Lobster	0.003	3.59	0.46	6.18	0.02	0.08	0.12	0.12	0.10
24. Sole, *Areliscus joyneri* (GÜNTHER)	1.13	0.92	0.65	1.06	1.20	1.01	1.25	1.03	1.22
25. Others	0.75	0.81	0.80	0.83	1.44	0.95	1.31	1.22	1.31

of various kinds of fishes, the above noticeable discordance in catch between the trawlers identical in vessel type but different in base port may obviously be attributed again to the intentional selection of fishing ground.

As seen in Table 6, about a half of the fish species there listed are not

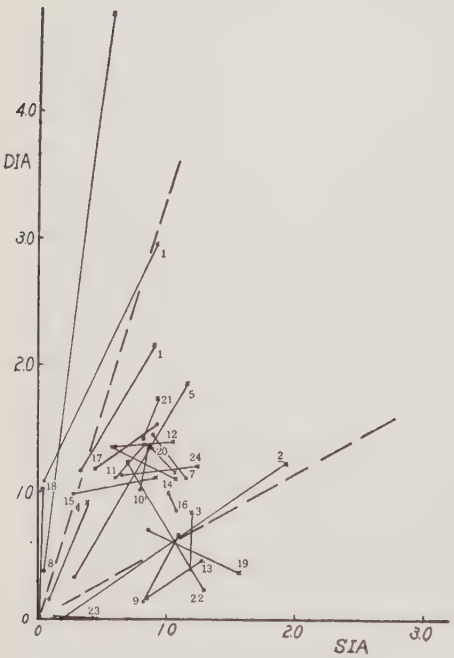

Fig. 2. Comparison of the fishing ability between 250–300 tons type steam trawler (SIA) and 250–300 tons type Diesel trawler (DIA), where ●, × stand for Shimonoseki and Tobata trawlers, respectively, and the numerals show the species of fish shown in Table 6.

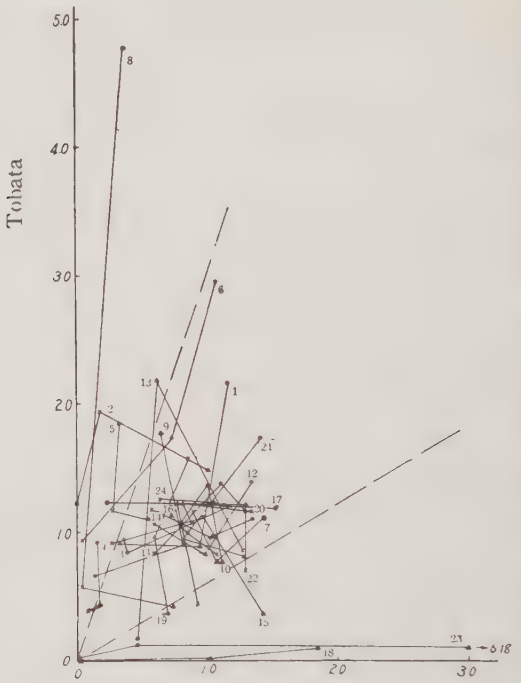

Fig. 3. Comparison of the fishing ability between Shimonoseki and Tobata otter trawlers of 250–300 tons Diesel type, 250–300 tons steam type and 350–500 tons steam type, where ●, ×, ▲ stand for the DIA, SIA and SII type trawlers, respectively, and the numerals show the species of fish shown in Table 6.

greatly different in respect of index of fishing ability between different bases as well as between vessels of different types, the situation apparently indicating homogeneous distributions of these fishes all over various sections of fishing ground. However, this apparent situation may not necessarily accord with the true state of distribution of these fish species because the data in Table 6 have not been prepared in consideration of "productivity of fishing ground," in the light of which the data will be looked at again as explained in the following section, and accordingly are possible to be under accidental balances between antagonistic effects of some factors on the calculation of fishing ability.

IV, 1, b. The fishing ability further rectified by productivity of fishing ground.

From the meaning of the term of "fishing ability" such a case is not impossible to be met with as that a small catch from a deserted fishing ground should be appraised as superior to a big catch from a fishing ground crowded with fishes. In the strict sense, therefore, any data for catches, whether they

are those by base or by some other variables such as vessel-type and fish species, cannot be correctly appraised without taking account of the thickness of fish distribution in the fishing ground section to which the data are concerned. In other words, comparison of fishing ability among data by individuals of a certain kind of variable, for instance, type of boat, can be done only under equivalency of each one of other variables inclusive of the condtion of fisihing ground.

Now, almost all kinds of bottom fishes in the East China and the Yellow Seas are very widely distributed and besides have large areas of migration according to the season, the fishing ground actually trawled, hence different species of fishes often covering almost whole the area of said seas. Accordingly, an approximate judgement can surely be made between different fishing gears or different fishing vessels about the superiority or inferiority of fishing ability for different species of fishes, insofar as their main schools stay in sea divisions trawled practically by all types of vessels. But in the case of such a species of fish as that main school of which scarcely comes into the fishing ground generally subjected to trawling, catch per draught is extremely influenced according to whether the species is chosen or not as the object of trawling, for the catch of such a special sort of fish can go out of the way from the general tendency of catch prevailing among other fishes. The exceptional cases with several kinds of catches pointed out in the foregoing section illustrate the situation just mentioned.

However, by establishing an idea of "productivity of fishing ground" and adopting the "coefficient of productivity", g_j, prepared on this idea as explained in Chapter III (cf. Equations (2) and (3)) the appraisal of fishing ability can be performed practically independent of possible singularity of any section of fishing ground. In the following, fishing ability by bases, by vessel-types and by caught fishes, respectively, will be treated with in consideration of productivity of fishing ground, the extreme high and low indices appearing in Table 6 being thereby made to turn substantially moderated ones as shown in Table 8. As to whether the discordance of index of fishing ability for a certain species of fish between different bases or vessels are truly attributable to choice of fishing ground or not, a final decision will be made first by referring to the data in Table 8 which have been prepared by recalculation in consideration of "productivity of fishing ground."

A chart of the former fishing ground sections over the East China and the Yellow Seas is shown in Fig. 4 according to the definition given by Japanese government. The fishing ground as a whole comprises 25 sections each of which was defined by drawing parallel lines on the chart at intervals of 30′ by latitude and longitude is shown in this figure as partitioned by lines drawn at intervals of 2°30′.

In the first place, using the "Catch Statistics of Otter Trawl and Pair Trawl Fisheries in the East China and the Yellow Seas" as reference, the mean catch per draught of porgy, *Chrysophrys major* (T. & S.), and other species gained by all trawlers actually operated in 1953 were calculated for every one of the above partitions of fishing ground. However, the item for cuttle fish, prawn and lobster in Table 6, being related to miscellaneous species inclusive of said ones each different in migration habit, was omitted this time from committing to discussion. In the practice of calculation, catch per draught is first evaluated as $C_{i,j}$, making all the trawlers the object of calculation, which were engaged in

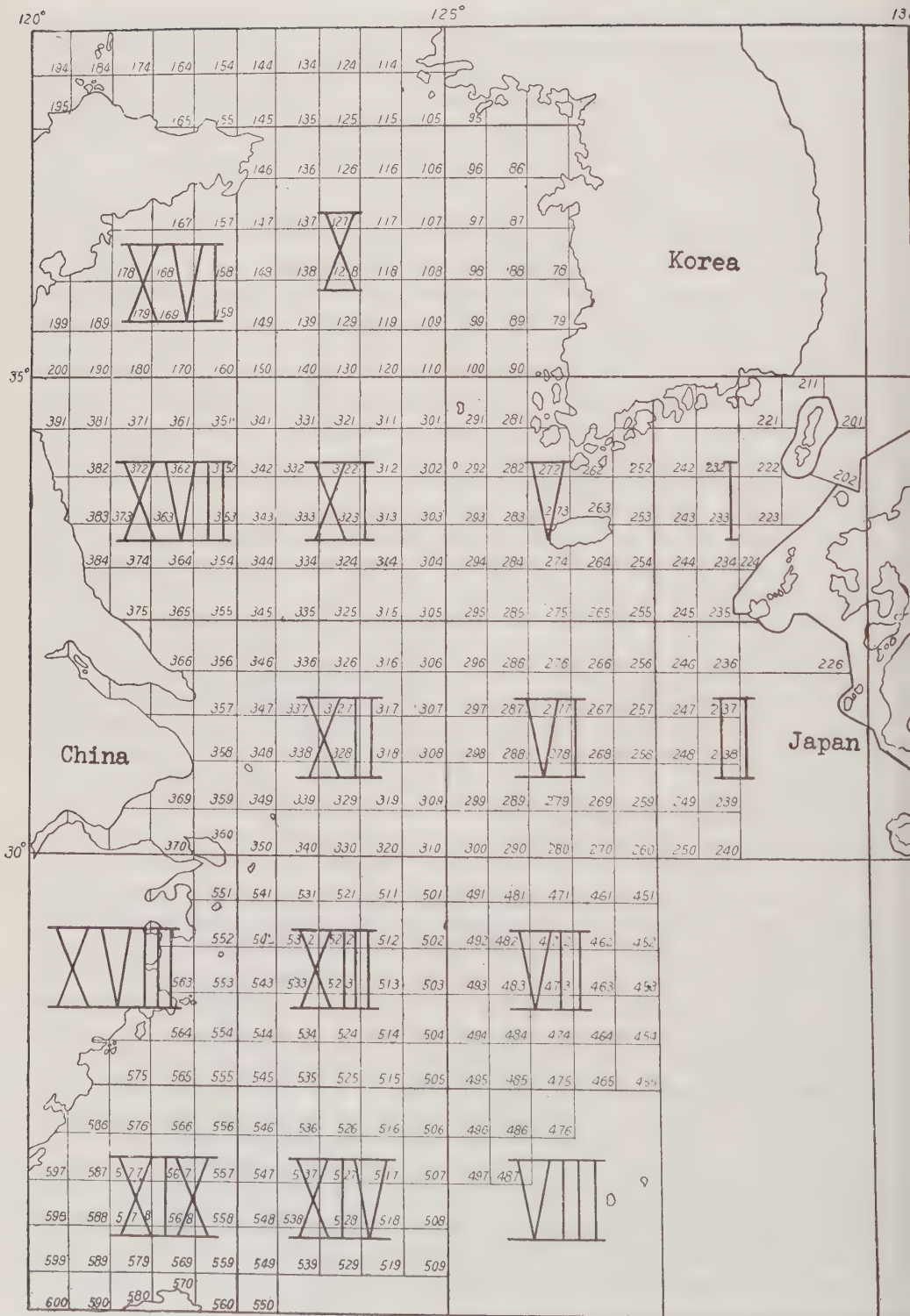

Fig. 4. Numbering of fishing ground sections established by the Japanese Ministry of Agriculture and Forestry, where the Roman and the Arabic numerals relate to abolished number and present one, respectively.

Table 7. Coefficient of productivity of fishing ground section for otter trawl fishries in 1953.

Notation of fish species	Fishing ground section											
	5	6	7	10	11	12	13	14	16	17	18	19
1	0.070	0.003	3.59	0.004	2.40	0.047	0.078	2.33	0	0.85	0.11	0.023
2	0	0.059	8.31	0	0	0	0.18	7.63	0	0	0	0.16
3	0.012	0.79	0	0	0.027	0.048	3.28	1.24	0	0	1.81	1.19
4	0	0.012	0	0	0	0.091	0.026	0	0	0	0.0009	6.98
5	0	0.32	0	0	0	0	2.53	0	0	0	0.013	3.42
6	0.018	0.012	0	0	3.11	0.19	3.83	0	0	0.52	0	0.043
7	0.58	2.48	0.19	0.35	1.02	1.98	0.73	0.25	0	0.92	0.20	0.44
8	0.00003	0.19	0	0	0.13	0.005	3.53	0	0	0	0.69	2.97
9	0.034	0.065	5.71	0	0.013	1.70	2.55	2.81	0	0	0.95	0.72
10	0.87	1.01	2.16	1.40	1.22	0.34	1.06	0	0	0.76	2.91	0.95
11	0.48	0.53	0	1.29	1.45	0.66	2.07	0	0.034	1.71	0.85	0.15
12	0.13	0.34	0	0	0.31	0.008	0.28	0.52	0	0	1.56	3.46
13	1.84	1.19	0.16	0.084	0.80	1.09	1.63	0.71	5.43	0.44	0.57	0.41
14	0.27	0.71	0.65	0.004	0.37	0.78	2.16	0.14	0	0.50	1.67	2.02
15	0.18	0.038	0	11.5	2.05	0.17	0.18	0	0	3.21	1.77	0.028
16	1.85	0.79	0	1.87	1.13	0.27	0.99	2.09	1.32	2.29	0.003	0.0007
17	0.91	0.15	3.27	4.16	1.06	0.042	0.59	0.81	0	1.45	0.57	1.15
18	0.002	0.002	0	3.06	0.73	0.042	0.16	4.34	7.78	4.40	0	0.00005
19	1.18	4.33	0	0.43	0.64	0.067	0.30	0	0	1.31	0.31	0.16
20	0.005	0.095	0.39	0	1.06	0.23	1.28	1.29	0	0	1.62	2.26
21	0.56	0.38	0	0.65	0.53	0.49	0.55	0.15	0	0.088	1.57	2.87
24	1.57	0.66	0.11	0.014	1.20	1.29	0.26	0	0	0	0.63	0.12

The numeral notations of fish species are the same as those shown in Table 6.

fishery in the i th month in the j th section of fishing ground. Then, monthly values averaged to the catch per draught in every one of fishing ground sections actually trawled are calculated as $S_i=\frac{1}{m}\sum_j C_{i,j}$ where m stands for the number of the fishing ground sections concerned. Further, an index, by means of which yearly fishing value of the j th fishing ground section can be represented, is calculated as $g_j=\sum_i C_{i,j}S_i/\sum_i S_i^2$. The values of g_j thus calculated for 22 fish species actually caught are listed in Table 7 by aforementioned partitions of fishing ground. As seen in the table the values of g_j are variant in a fairly wide range according to fishing ground section as well as fish species.

In the second place, referring to the data of catch reported by all trawlers operated, monthly catches of 22 fish species including porgy were totaled not only by fishing bases but also by vessel-types for each one of aforementioned partitions of fishing ground. From these total values, the values for catch per draught assignable respectively to the groups of vessels particularized in the terms of vessel-type and home base were determined. Using the values thus determined, yearly

Table 8. Coefficient of fishing ability calculated by Equation (5), by base port, type of vessel and species of fish for otter trawlers in 1953.

Base port		Shimonoseki				Tobata				
Notation of fish species	Type of vessel	DIA	DIB	SIA	SII	DIA	SO	SIA	SIB	SII
	1	0.99	1.43	0.51	1.09	1.76	0.36	0.89	0.70	0.91
	2	0	1.14	0.042	0.98	0.89	0.62	1.08	1.06	2.23
	3	1.62	0.62	1.19	0.13	2.26	1.12	0.67	1.89	0.21
	4	0.42	1.84	0.29	0.28	0.015	0.97	0.35	0.37	1.09
	5	1.15	1.16	0.77	1.22	1.80	1.09	0.88	2.67	1.28
	6	0.85	0.57	0.096	1.32	1.99	1.49	0.95	1.97	1.90
	7	0.88	0.97	1.19	1.03	0.99	0.56	0.69	0.71	0.51
	8	0.48	1.18	0.47	1.00	1.49	0.31	0.94	0.19	0.39
	9	0.65	0.91	0.51	1.07	1.19	1.19	1.28	1.17	1.36
	10	0.95	1.34	0.89	0.97	1.49	0.71	1.30	0.73	0.76
	11	0.88	1.07	0.51	0.86	0.73	0.61	0.45	0.70	0.97
	12	1.18	1.20	0.82	0.65	1.08	1.30	0.98	1.04	1.04
	13	0.90	0.48	1.03	0.70	0.30	1.03	0.64	1.89	1.80
	14	1.14	1.09	0.68	0.63	0.96	0.65	0.66	0.87	0.72
	15	1.13	2.86	0.22	2.04	0.86	0.25	0.86	0.72	0.49
	16	1.22	1.02	0.94	0.92	1.07	0.88	1.15	0.75	1.11
	17	1.01	0.56	0.88	0.44	0.89	0.23	0.51	0.51	0.57
	18	1.08	2.14	0.022	1.00	0.007	0.002	0.004	0.002	0.23
	19	1.20	1.13	0.97	0.81	1.21	1.19	1.13	1.36	0.90
	20	0.70	0.81	1.07	0.54	2.16	0.84	1.03	0.66	1.02
	21	0.73	0.61	0.58	1.00	0.73	0.34	0.65	0.60	0.45
	24	1.18	0.73	1.01	1.15	0.70	0.78	0.94	1.00	1.07

The numeral notations of fish species are the same as those shown in Table 6.

indices of fishing ability were calculated by the help of Equation (3) each for different types of fishing vessels by their home bases, the results being shown in Table 8.

On the basis of the tabular matters here presented, fishing abilities of trawlers Shimonoseki base and Tobata base may be submitted to the following discussion:

Comparing the indices of fishing ability for 250-300 tons Diesel trawlers (DIA) with corresponding ones for 250-300 tons steam trawlers (SIA) by the help of a schema given in Fig. 5, they are found to be roughly in the ratio 10:8 for many kinds of fishes. However, the values for gurnard, flounder, *Paralichthys olivaceus* (T. & S.), and sea robin caught by Shimonoseki trawlers and crimson sea bream and hairtail of Tobata trawlers are out of the general tendency, attesting to practised choice of fishing ground. Every Diesel trawler is operated by an engine working at 200 230 Rev/min and drags the net with a velocity of 3.0 3.5 knots/hour, while every steam trawler is operated by an engine at 70-90 Rev/main and drags the net at a speed of 2.0-3.0 knots/hour. Accordingly, the speed of drag of Diesel trawlers is $3.0-3.5/2.5-3.0=1.20-1.17$ times as large as

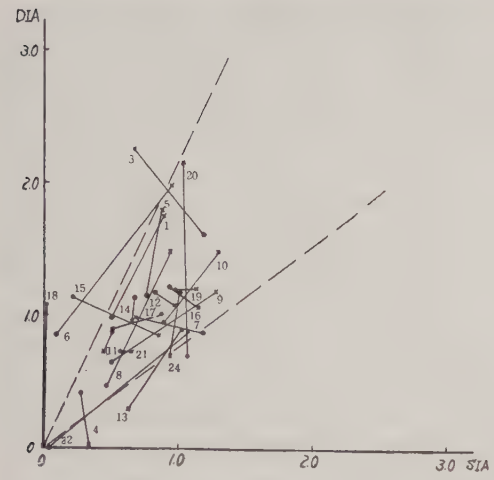

Fig. 5. Comparison of fishing ability between 250–300 tons steam Trawler (SIA) and the 250–300 tons type Diesel trawler (DIA), where ●, × stand for Shimonoseki and Tobata trawlers, respectively, the numerals showing the species of fish listed in Table 6.

that of steam trawlers.

However, the time Diesel vessels require per draught is somewhat shorter in general than that required by steam vessels, the ratios being on the average 3.62:3.65 (=0.99) and 3.38:3.70 (=0.91) for Shimonoseki and Tobata bases, respectively. Hence, in respect of the area swept in a draught, said two types of

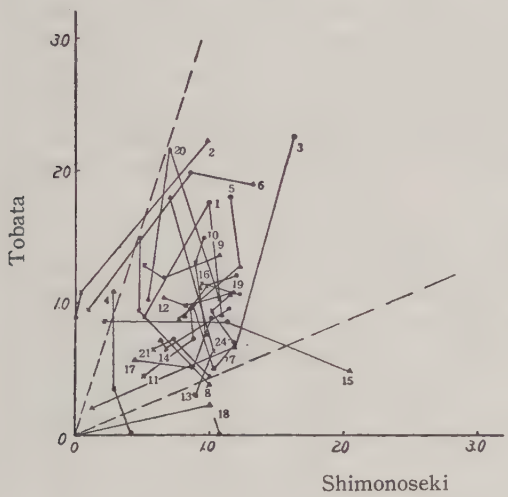

Fig. 6. Comparison of fishing abilities of Shimonoseki and Tobata trawlers between 250–300 tons type steam trawler (SIA), 250–300 tons type Diesel trawler (DIA) and 350–500 tons type steam trawler (SII), respectively, where ●, ×, ▲ stand for DIA, SIA and SII type trawlers, respectively, the numerals showing the species of fish listed in Table 6.

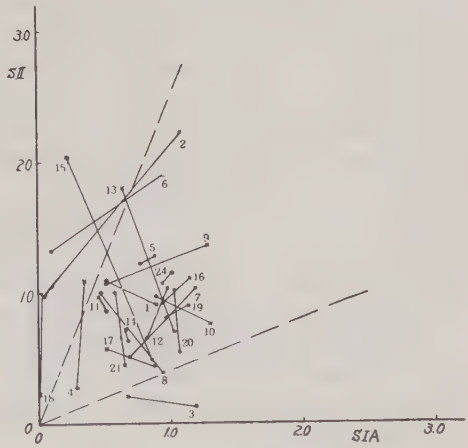

Fig. 7. Comparison of fishing ability between 250–350 tons type (SIA) and 350–500 tons type (SII) steam trawlers, where ●, × stand for Shimonoseki and Tobata trawlers, respectively, the numerals showing the species of fish listed in Table 6.

vessels may be said to have charge of extensions, respectively, which are in the ratio $1/2(1.20+1.17)\times 1/2(0.99+0.91):1$ or, roughly appraising, 10:9. With trawlers of an equal realm of tonnage, either type of vessel is equally equipped with definite kinds of fishing gear. Since, according to Dr. Honda's[1] result of model experiments, the extent to which mouth of trawl net is kept opened during draught at a speed above 2.5 knots differs scarcely between Diesel and steam vessels, the above ratio 10:9 is though to hold also for fishing ability. In this viewpoint, therefore, the smaller ratio 10:8 found in dealing with Table 8 may likely represent a modification due to the difference in effective catch, which in turn arises from the difference in towing velocity.

Next, when fishing ability of 250–300 tons Diesel trawlers (DIA), 250–300 tons steam trawlers (SIA) and 300–500 tons steam trawlers (SII) are respectively compared between Shimonoseki base and Tobata base by picking up the data concerned from Table 8 and plotting them as shown in Fig. 6, these three series of fishing abilities are found for many species of fish each to be roughly in the ratio 9:10 with the exception of those for crimson sea bream, sea robin and snapper caught by DIA, snapper and gurnard by SIA and flounder and sea robin by SII, in regard of which the ratios between different bases deviate widely from said general tendency. This deviation seems to have arisen surely from the difference of trawled sections of fishing ground between Shimonoseki vessels and Tobata ones or from uneven distribution of these fish species.

As regards the time required in a draught, on the other hand, the three types of vessels under question are in the ratio 3.62:3.38 (=1.07), 3.65:3.70 (=0.99) and 3.41:3.49 (=0.98), respectively, between Shimonoseki base and Tobata base. These ratios may roughly be looked upon as equally 10:9.9, telling the absence of difference in the time taken in a draught between the two bases. The ratios of fishing abilities 9:10 revealed by plotting the data in the schema of Fig. 6 may thus be considered to indicate some difference likely existing between fishing gears of trawlers of these bases.

Further, from schematic comparisons as given in Fig. 7 between the data for DIA and SII vessels listed in Table 8, the following state of affairs may be noticed: While these two types of trawlers are of equal fishing ability for many kinds of caught fishes, some of the data are obviously under the influence of the preference by sampled individuals of trawlers of fishing ground or of fish species to be caught as it is the case with the data for snapper, gurnard, blanquillo, *Branchiostegus* sp., sea rabin and flounder of Shimonoseki trawlers and sea robin of Tobata ones.

V. Fishing Ability of Pair Trawl Fishery

V, 1. Fishing ability of pair trawl fishery by base ports and vessel-types in the aspect of total catch.

To begin with, on reference to the "Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas," comparative fishing abilities of each base port and each type of vessel will be appraised for the years of 1951, '52 and '53, respectively, without taking account of the difference in species of caught fishes.

According to this publication, fishing vessels concerned are classified into those of 30–50 tons (C), 50–70 tons (B) and 70 tons and above (A) with pair trawlers and into those of 30–50 tons (C′), 50–70 tons (B′) and 70 tons and above (A′) in the case of triplet trawlers.* Number of trawlers operated in Decembers of 1951, '52 and '53, respectively, is reproduced in Table 9 by their bases as well as by vessel-types. Whereas the number of trawlers registered remained nearly constant, that of trawlers actually operated is found decreasing year by year.

As shown in Tables 10, 11 and 12, as to monthly average duration of trip in days per trawler for each base and each type of vessel evaluated relative to that for all bases and all vessel-types concerned, the values calculated for pair trawl fall in the ranges of 0.76–1.11, 0.77–1.09 and 0.78–1.11 for 1951, '52, and 53, respectively, and those for triplet trawl are 2.00 and 2.62 for 1952 and '53, respectively. Further, as regards to monthly average number of practice of hauling for each pair trawl by bases and vessel-types appraised relative to that for whole bases and for whole vessel-types of pair trawl, the values fall in the

Table 9. Number of the pair trawlers registered and actually operated for each base port and type of vessel.

	Base port	Shimonoseki				Hagi	Tobata		Fukuoka			
	Type of vessel	A	B	C	A′	C	A	C	A	B	C	A′
1951	Registered vessel	165	38	39	—	18	56	3	67	89	13	—
	Actually operated	150	32	39	—	10	50	2	50	82	12	—
1952	Registered vessel	111	42	43	45	18	40	3	83	77	12	6
	Actually operated	93	28	40	44	18	40	3	64	74	10	5
1953	Registered vessel	100	44	29	67	18	38	3	105	57	10	2
	Actually operated	76	40	21	51	16	30	—	86	54	8	1

	Base port	Imari		Karatsu		Nagasaki				Saseho		Kuma-moto	Total
	Type of vessel	A	B	A	B	A	B	C	A′	B	C	A	
1951	Registered vessel	2	14	4	6	100	136	18	—	4	16	2	790
	Actually operated	2	10	4	6	92	130	18	—	2	16	—	707
1952	Registered vessel	—	12	6	4	107	137	14	—	4	18	2	786
	Actually operated	—	10	4	4	97	116	8	—	4	18	2	678
1953	Registered vessel	4	12	6	2	117	133	8	3	4	20	2	784
	Actually operated	—	8	6	2	90	132	6	3	4	16	2	652

* The term "triplet trawlers" means that a unit of fishing means comprises three trawlers of which one returning to base port when her holds get filled with catch.

ranges of 0.58–1.21, 0.69–1.38 and 0.38–1.48 for 1951, '52 and '53, respectively. Having regard to the yearly fluctuation in the above values, neither catch per trip nor catch per month seems as the material suitable to be directly availed in expressing the catch per unit effort. In this point of view, in the following re-

Table 10. Fishing ability by base port and type of vessel for pair trawlers in 1951.

Base port	Shimonoseki				Hagi	Tobata		Fukuoka			
Type of vessel	A	B	C	A′	C	A	C	A	B	C	A′
Coefficient of fishing ability	1.02	0.96	0.76	—	0.57	0.91	0.53	1.11	0.97	0.81	—
Average operation time per draught in hours	1.75	1.33	1.84	—	1.58	1.86	1.94	2.10	2.04	2.20	—
Average number of draught per month	58	47	45	—	39	55	35	47	43	40	—
Average number of fishing days per month	12.0	11.8	11.2	—	9.2	12.2	11.6	12.3	11.6	10.5	—

Base port	Imari		Karatsu		Nagasaki				Saseho		Kuma-moto	Mean
Type of vessel	A	B	A	B	A	B	C	A′	B	C	A	
Coefficient of fishing ability	1.09	0.99	1.22	0.93	1.17	0.99	0.84	—	0.80	0.73	1.04	1.00
Average operation time per draught in hours	2.28	2.06	2.15	2.04	1.86	2.06	2.00	—	2.16	2.70	2.00	1.94
Average number of draught per month	51	44	41	45	48	44	39	—	34	28	36	48
Average number of fishing days per month	11.8	11.2	11.7	12.8	12.6	11.5	10.9	—	8.8	9.0	10.3	11.6

Table 11. Fishing ability by base port and type of vessel for pair trawlers in 1952.

Base port	Shimonoseki				Hagi	Tobata		Fukuoka			
Type of vessel	A	B	C	A′	C	A	C	A	B	C	A′
Coefficient of fishing ability	0.97	0.86	0.68	0.82	0.64	0.89	0.44	1.07	0.92	0.72	1.12
Average operation time per draught in hours	1.84	1.91	1.81	1.70	1.81	1.77	1.38	2.03	2.02	2.21	2.15
Average number of draught per month	61	52	52	68	41	60	72	51	47	42	49
Average number of fishing days per month	12.3	11.8	11.8	25.9	11.2	12.7	16.0	12.4	12.1	11.0	22.6

Base port	Imari		Karatsu		Nagasaki				Saseho		Kuma-moto	Mean
Type of vessel	A	B	A	B	A	B	C	A′	B	C	A	
Coefficient of fishing ability	1.09	0.84	1.07	0.88	1.16	0.94	0.87	1.17	0.66	0.91	1.00	1.00
Average operation time per draught in hours	3.20	2.03	2.09	2.02	2.03	2.03	2.02	2.03	2.08	2.66	1.87	1.93
Average number of draught per month	50	53	41	45	51	45	45	45	39	36	52	52
Average number of fishing days per month	13.4	12.6	11.2	11.9	12.4	11.8	11.8	25.0	10.0	10.8	14.1	12 9

Table 12. Fishing ability by base port and type of vessel for pair trawlers in 1953.

Base port	Shimonoseki				Hagi	Tobata		Fukuoka			
Type of vessel	A	B	C	A′	C	A	C	A	B	C	A′
Coefficient of fishing ability	0.92	0.89	0.72	0.91	0.55	0.72	0.72	1.13	0.95	0.80	1.02
Average operation time per draught in hours	1.73	1.87	1.88	1.71	1.72	1.69	2.04	1.99	2.10	2.14	2.01
Average number of draught per month	66	50	52	83	44	68	21	56	50	55	57
Average number of fishing days per month	12.6	11.8	12.1	32.0	10.7	12.9	8.9	12.6	12.2	12.9	26.3

Base port	Imari		Karatsu		Nagasaki				Saseho		Kuma-moto	Mean
Type of vessel	A	B	A	B	A	B	C	A′	B	C	A	
Coefficient of fishing ability	1.27	0.95	1.20	1.04	1.24	1.04	0.88	0.84	0.92	1.17	1.05	1.00
Average operation time per draught in hours	2.25	2.08	1.86	2.01	2.02	2.09	1.98	2.09	2.38	2.77	1.87	1.94
Average number of draught per month	36	50	54	49	53	48	48	39	46	35	44	56
Average number of fishing days per month	9.4	12.2	13.6	11.9	12.2	12.2	12.4	21.9	17.8	11.9	12.2	12.2

presentation of catch per unit effort, it will be used as the material, similarly to the case of otter trawl, monthly average catch per draught.

Using monthly mean catch per draught attained by all pair trawlers operated in each month (S_i for the ith month), calculation of index of fishing ability was performed by means of Equation (5) for each base port and each type

of vessel, the results being also given in Tables 10, 11 and 12. To be disappointed, however, as seen in these tables, the values for average duration of draught thus evaluated for different base ports and different vessel-types are found scattered very widely around the corresponding values calculated for pair trawlers all the concerned inclusive, ratios between these two series of values fluctuating in the ranges of 0.58–1.21, 0.69–1.38 and 0.38–1.48 for 1951, '52 and '53, respectively. The above strong scattering may indicate that Equation (5) does not make in this case a means for obtaining values of fishing ability; some additional considerations seem to be necessary.

As a matter of fact, catch per draught increases with increasing time of draught. The values of index of fishing ability calculated only by using the values of average catch per draught are therefore possible to be affected by time of draught which may in turn be possible to fluctuate and under certain circumstances even to a serious extent. Then, by what procedure of calculation can the effect of time of draught be canceled in using catch per draught for apprais-

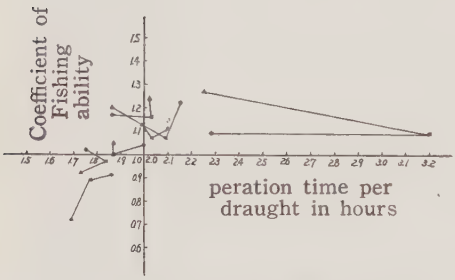

Fig. 8. Relation between average operation time per draught and coefficient of fishing ability of pair trawlers of 70 tons and above type, where ●, ×, ▲ stand for 1951, '52, '53, respectively.

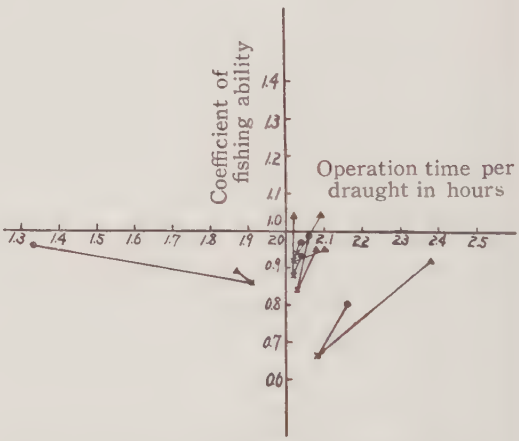

Fig. 9. Relation between average operation time per draught and coefficient of fishing ability of 50–70 tons type pair trawlers, where ●, ×, ▲ stand for 1951, '52, '53, respectively.

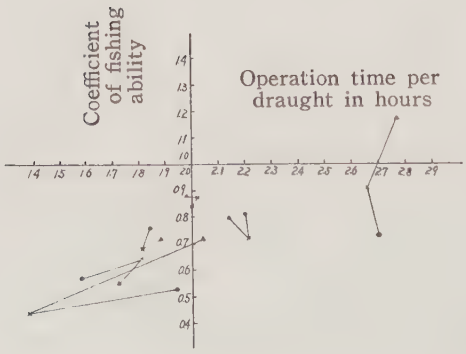

Fig. 10. Relation between average operatime per draught and coefficient of fishing ability of 30–50 tons type pair trawlers, where ●, ×, ▲ stand for 1951, '52, '53, respectively.

ing index of fishing ability? By way of suggestion, values of index of fishing ability listed in Tables 10, 11 and 12 are plotted against time of draught as shown in Figs. 8, 9 and 10 for the above-mentioned classes of vessel tonnage of A, B and C, respectively. These figures indicate that excepting a few cases exemplified by the data for Type A vessel of Imari base in 1952, Type B vessel of Shimonoseki base in 1951 and Type C vessel of Saseho base in 1951, especially those for Type B vessel of Saseho base in the three years concerned, there prevails a general tendency of linearly increasing of index of fishing ability with increasing time of draught for any class of pair trawlers.

It is considered that the longer time of draught results in the smaller number of draught and *vice versa*. In comparing fishing ability between different vessel-types and different base ports, therefore, the values for index of fishing ability calculated only with resort to catch per draught are considered to be put to practical use first under the weight of the corresponding values for number of draught. Thus, multiplying the indices of fishing ability in Tables 10, 11

Table 13. Revised coefficient of fishing ability by base port and type of vessel for pair trawlers.

Base port \ Type of vessel	A	B	C	A′
Shimonoseki	1.15	0.90	0.69	1.16
Hagi	—	—	0.47	—
Tobata	0.98	—	0.42*	—
Fukuoka	1.09	0.85	0.68	1.04*
Imari	1.01*	0.87	—	—
Karatsu	1.01	0.85	—	—
Nagasaki	1.17	0.87	0.73	0.80*
Saseho	—	0.61*	0.60	—
Kumamoto	0.75*	—	—	—

* The case wherein only a small of registered vessels were operated.

and 12 by the corresponding monthly number of draught and averaging these products between three years of 1951–1953, the values of relative fishing ability by base ports as well as by vessel-types were obtained as shown in Table 13.

It is understood from the data in this table that, excepting the several cases in which the number of actually employed vessels was particularly small, in respect of average yearly index of fishing ability, vessels of 70 tons and above show a value falling in a range of 1.17–0.98 irrespective as to whether they are of pair trawl or of triplet trawl, those of 50–70 tons a value in a range of 0.90–0.85 and those of 30–50 tons a value between 0.73 and 0.60, a rather small scattering in every case but for the exceptional low value, 0.47, for trawlers of Hagi base. As a matter of course, reported time taken per draught comprises not only the time required in the operation of gathering up fishes by trawling proper but also that taken in preparations for hauling up the net. Since the catch brought on board after the last trawling is necessary to be entirely placed in holds before hauling up the net is started, time per draught is possible to vary occasionally

as reflected in the data of Tables 10, 11 and 12. Nevertheless, so far as a definite type of vessel is concerned, index of fishing ability, when revised in consideration of time per draught or number of draught as above, turns out almost invariable between different base ports. This means, perhaps, that, independent of the time taken in gathering up fishes by trawling proper, the operation just prior to hauling up the net, namely, mutual approach followed by running side by side of partner ships for final securing gathered fishes is completed under an almost invariable condition. The variance of index of fishing ability between different vessel-types, on the other hand, as inferred from its gradual decrease with decreasing tonnage, many perhaps be due to the difference in size of trawl net employed by vessels different in type.

V,2. Fishing ability of pair trawl fishery by base ports, vessel-types and fish species.

Catch obtained by pair trawl from the East China and the Yellow Seas is composed of a variety of fish species as it is the case with otter trawl fishery. However, as to the percentages of various fish species referred to total catch, as seen from the past data that even the catch of yellow croaker which is caught in greatest plenty does not exceed 13.6%, pair trawl fishery is distinguished from otter trawl fishery in that the former is scarcely operated in aiming at a certain particular fish species by preference. Now, fishing ability of pair trawl will be comparatively examined in the same manner as in the case of otter trawl among different species of caught fishes.

As A type pair trawl designated as such in the Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas represents a number of vessels of 70 tons and above covering a fairly wide range of tonnage, this type of vessels are further classified for convenience sake in this paper into classes of 70–90 tons (1A), 90–100 tons (2A), 100–115 tons (3A) and 115–140 tons (4A). These pair trawl vessels may also be differentiated into four categories in aspects of hull-bilding material and main engine, that is, steel vessels with Diesel engines, those with semi-Diesel engines, wooden vessels with Diesel engines and those with semi-Diesel engines. All of the pair trawlers under 50 tons are of wooden hull and semi-Diesel engine. Most of 50–70 tons trawlers are also of this category except that, with Nagasaki trawlers falling in said range of tonnage, vessels of wooden hull go halves with those of steel hull, while some of 50–70 tons trawlers are driven by Diesel engines. The trawlers of 70–90 tons type are almost all of steel hull and have Diesel engines with the exception of Fukuoka trawlers which are for the most part of wooden hull and driven by Diesel engines. Large pair trawlers of 90–100 tons and above are all of steel hull and equipped with Diesel engines.

Fishing grounds favored by different bases do not agree in geographic position even with vessels comparative large in tonnage and hence also in crusing power. Thus, in the case of pair trawlers of 70–90 tons and 90–100 tons, draughts by Shimonoseki and Tobata vessels are performed every year up to 80–90% in the northern part of the East China and the Yellow Seas and to 10–20% in the southern part of the East China Sea, while those of Fukuoka, Karatsu and Nagasaki trawlers to 40–50% in the former sea region and to 50–60% in the latter region. In the case of comparatively small trawlers, fishing grounds they can choose are still more strongly influenced by their base ports. In order to make

use of existing data in appraising fishing ability of pair trawl fishery, therefore, said variation of fishing ground with base port and vessel type must be removed of its effect on the appraisal, otherwise the variation will lead to more numerous abnormalities than in the case of otter trawl. From this point of view, in the following appraisal of fishing ability for pair trawl, effect of the geographic diverseness of fishing ground has been evaded as completely as possible by hav-

Table 14. Coefficients of productivity of fishing ground sections subjected to pair trawl fishery in 1953.

Fishing ground section	Notation of fish species											
	1	2	7	8	9	10	11	12	13	14	15	19
1	0.051	0.94	0.11	0.19	0.48	0.079	0.005	0.007	0.074	0.028	0.71	0.069
2	0.12	1.50	0.042	0.18	0.69	0.060	0.070	0.086	0.17	0.16	0.20	0.62
5	0.044	0.65	1.08	0.080	0.18	0.42	1.16	0.086	5.30	0.43	0.41	0.57
6	0.016	0.65	2.33	0.49	0.39	0.57	1.10	0.81	0.55	0.58	0.056	1.89
7	0.029	2.55	0.26	1.22	1.94	0.17	0.009	0.21	0.23	0.42	0.025	0.67
8	0.012	1.06	0.50	0	1.56	0.42	0.20	0.17	0.13	0.33	0	0.20
9	0	0	0.36	0	0	0.26	3.50	0	0.20	0.11	2.89	0
10	1.44	0	0.19	0.023	0.087	1.14	2.12	0.015	0.051	0.089	6.65	0.18
11	0.047	0.009	1.51	0.23	0.039	0.30	4.46	0.032	0.67	0.26	1.77	0.30
12	0.011	0.022	2.28	0.57	0.43	0.94	1.84	0.43	1.15	3.92	0.12	0.46
13	0.029	0.78	1.59	1.23	1.84	0.87	0.93	1.85	2.60	1.65	0.13	2.76
14	0.048	3.71	0.23	0.57	2.56	0.095	0.039	0.16	0.14	0.18	0.006	2.87
16	6.34	0	1.20	0	0.29	2.11	0.83	0.16	1.04	1.33	0.73	0.69
17	7.90	0.065	1.74	1.00	0.25	1.03	0.85	1.29	0.54	1.98	2.96	0.13
18	0.006	0.29	1.59	1.99	1.09	1.68	1.13	4.41	0.68	2.55	0.22	1.00
19	0.030	1.82	0.39	6.38	2.06	0.54	0.25	4.55	0.48	0.95	0.038	1.82

The numeral notations of fish species are the same as those shown in Table 6.

ing resort to a procedure of calculation similar to that adopted for otter trawl, that is, by introducing the idea of "productivity of fishing ground."

Using the datain "Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas" average monthly catch per draught in each fishing ground section, $C_{i,j}$, (in the present paper according to the former definition thereof) was calculated for porgy and other eleven fish species on the basis of catches attained by whole pair trawlers concerned and further arithmetic mean of $C_{i,j}$ over whole fishing ground sections, S_i. Putting the values of $C_{i,j}$ and S_i in Equation (2), yearly index of productivity of fishing ground was calculated for each fishing ground section as well as for each fish species, the results being shown in Table 14.

Fishing reports from all pair trawlers being rearranged in aspects of fish species, fishing ground section, base port and type of vessel, the corresponding values of average monthly catch per draught were computed, yearly indices of fishing ability by fish species, base ports and vessel-types being further calculated, leading to the results shown in Table 15.

Table 15. Coefficient of fishing ability calculated by Equation (5) by base port, type of vessel and species of fish for pair trawlers in 1953.

Base port	Type of vessel	Notation of fish species											
		1	2	7	8	9	10	11	12	13	14	15	19
Shimonoseki	4A	0.33	0.015	1.34	0	0.85	1.87	1.82	0.49	1.29	0.33	3.24	0.073
	3A	0.036	0	4.43	0.74	0.65	0.69	0.81	0.040	0.64	0.16	1.61	0.018
	2A	3.89	0.21	1.24	0.11	0.64	1.03	1.08	0.37	0.42	0.16	0.59	0.22
	1A	5.39	1.60	1.48	0.18	0.39	1.22	1.22	0.22	0.71	0.29	0.38	0.31
	B	0.38	0.53	0.74	4.11	0.87	1.12	1.03	0.080	0.60	0.64	0.30	0.56
	C	0.78	0.58	0.11	0.70	0.73	0.77	0.44	0.37	2.33	0.18	0.70	0.63
	1A′	3.06	0.006	1.52	0.38	0.56	1.60	1.34	0.28	0.62	0.39	1.07	0.33
Hagi	C	1.05	0.53	0.39	19.7	0.73	1.36	0.31	1.18	5.01	4.39	0.70	2.49
Tobata	2A	2.31	0.0009	1.86	0.21	0.22	0.26	2.17	0.51	0.27	0.13	0.29	0.26
	1A	0.32	0.019	2.26	0.083	0.15	0.14	2.42	0.49	0.58	0.29	12.6	0.18
	C	47.7	0.53	1.33	0	0.23	11.1	7.16	0	0	0	0	0
Fukuoka	2A	0.68	0.025	0.30	0.65	0.44	2.82	0.23	0.80	0.65	0.65	0.20	1.80
	1A	1.86	0.32	0.71	1.13	2.22	1.44	0.53	0.48	0.63	0.37	0.53	0.96
	B	0.20	0.54	0.67	0.53	0.65	0.25	0.12	0.36	1.50	0.30	0.13	1.51
	C	1.87	1.40	0.043	5.40	2.04	1.31	0.097	0.80	0.18	0.29	8.45	0.79
	1A′	0.75	0.67	0.87	0	0.19	2.96	1.64	0.80	1.07	0.55	0.42	0.43
	1A″	0	0.63	1.17	0	1.16	0.082	0.68	0	0.61	3.33	0	0
Imari	2A	3.05	1.78	0	24.3	3.43	5.11	0.037	0.53	0.41	0.21	0	0.073
	1A	0	0.93	0	0	1.07	0.052	0.027	1.72	0.015	0.59	0	0
	B	0.43	0.18	0.49	0.89	1.15	2.75	0.70	1.71	0.67	1.57	3.95	1.64
Karatsu	1A	0.38	0.15	0.30	0.088	1.30	2.21	0.036	1.21	2.69	0.37	0.76	1.75
	B	0.041	0.082	0.88	0	2.19	2.38	0.024	1.96	0.81	0.40	0	3.38
Nagasaki	2A	1.29	0 38	2.11	0.025	0.92	1.54	1.63	0.58	1.16	0.54	0.33	0.30
	1A	1.74	0.61	1.16	0.36	1.62	2.32	1.55	1.42	0.71	0.35	0.27	0.47
	B	1.15	0.58	1.43	0.36	0.70	1.89	0.99	0.37	0.57	0.51	0.73	0.85
	C	2.64	2.39	0.25	0.006	1.65	1.30	0.59	0.62	0.35	0.86	0.62	0.39
	1A′	0.20	0.084	1.86	0	0.34	1.54	1.38	0.035	0.98	1.02	0.054	0.077
Saseho	B	1.34	2.18	0.033	0.65	0.56	2.88	0.033	0.30	0.16	0.31	1.00	1.07
	C	1.80	2.39	0.038	0.21	1.41	0.078	0.0001	0.006	0.22	0.029	2.09	0.028
Kumamoto	1A	0.80	0.38	0.087	0.004	2.99	0.86	0	0.46	1.01	0.73	0	0

The numeral notations of fish species are the same as those shown in Table 6.

From the data in this table, the following inferences may be drawn as regards fishing ability of pair trawl fishery:

Comparing the fishing ability between 2A vessels and 1A vesseles as illustrated in Fig. 11, these two types of trawlers are found in respect of fishing

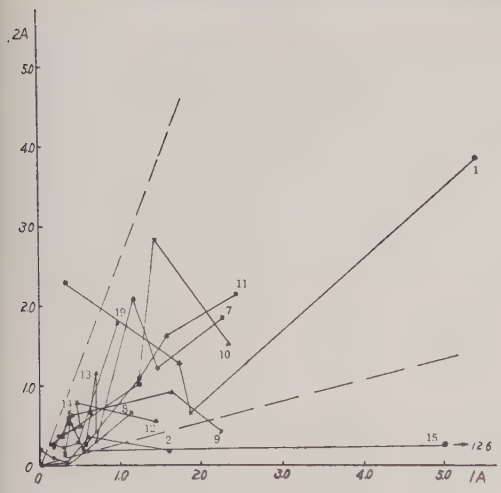

Fig. 11. Comparison of fishing ability between 70–90 tons (1A) and 90–100 tons type (2A) pair trawlers, where ●, ■, ×, ▲, stand for Shimonoseki, Tobata, Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

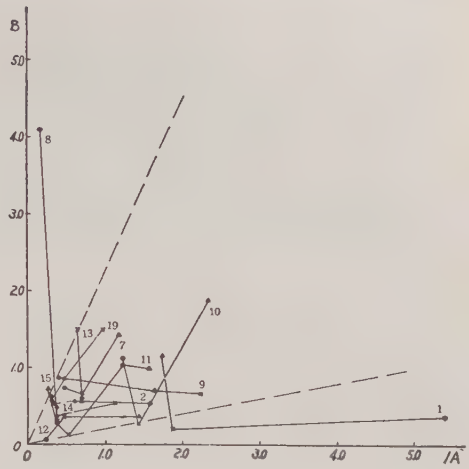

Fig. 12. Comparison of fishing ability between 50–70 tons type (B) and 70–90 tons type (1A) pair trawlers, where ●, ×, ▲ stand for Shimonoseki, Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

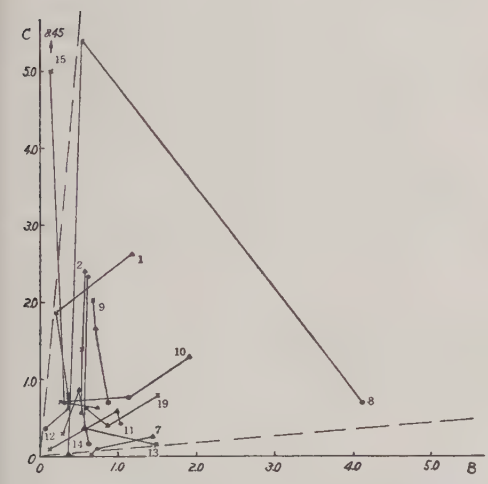

Fig. 13. Comparison of fishing ability between 30–50 tons type (C) and 50–70 tons type (B) pair trawlers, where ●, ×, ▲ stand for Shimonoseki, Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

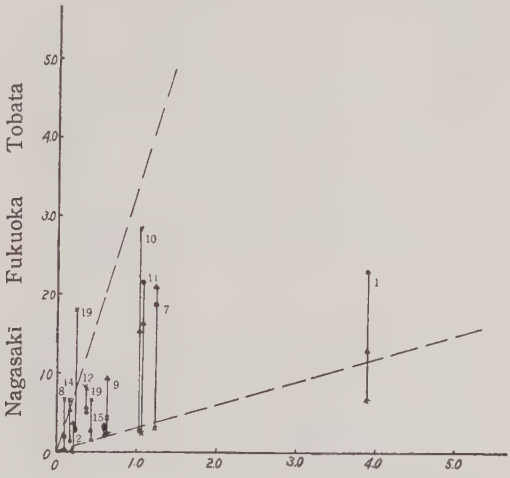

Fig. 14. Comparisons of Tobata, Fukuoka and Nagasaki pair trawlers, respectively, to Shimonoseki pair trawler in respect of fishing ability of 90–100 tons type pair trawler, where ●, ×, ▲ stand for Tobata, Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

ability to be roughly in the ratio 9:10, the singular values met with for progy and flounder of Tobata and snapper of Shimonoseki seeming to be due to choice of fishing ground. The ratio of fishing ability of B vessels to that of 1A seems to be roughly 8:10 as judged from the plottings in Fig. 12 wherein the singularity found for porgy and large croaker of Shimonoseki is again taken as a result of preference of fishing ground. According to Fig. 13, fishing ability of B and C vessels appear to be in the ratio 1:1, though not to be said so with confidence

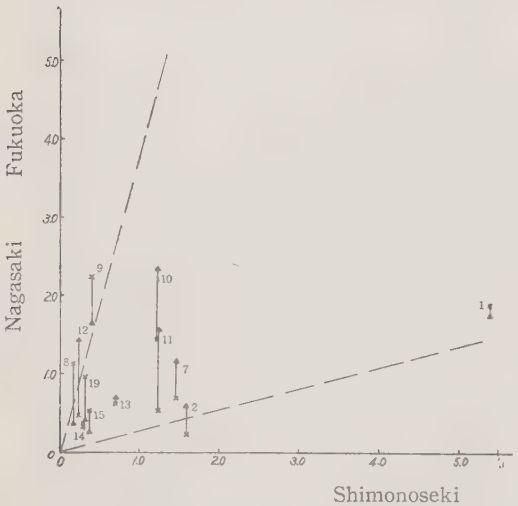

Fig. 15. Comparisons of Fukuoka and Nagasaki pair trawlers, respectively to Shimonoseki pair trawler in respect of fishing ability of 70-90 tons type pair trawler, where ×, ▲ stand for Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

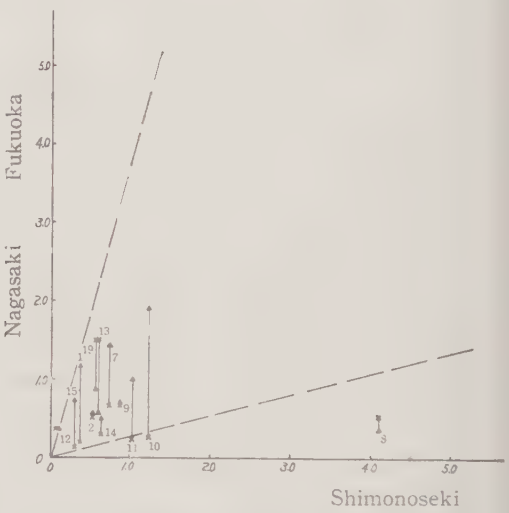

Fig. 16. Comparison of Fukuoka and Nagasaki pair trawlers, respectively to Shimonoseki pair trawler in respect of fishing ability of 50-70 tons type pair trawler, where ×, ▲ stand for Fukuoka and Nagasaki trawlers, respectively, the numerals showing the species of fish listed in Table 6.

because of the extreme abnormality found for croaker of Fukuoka and flounder of Nagasaki. While reliable comparison of fishing ability is made the more difficult the smaller the vessel concerned, fishing abilities of 2A, 1A, B and C seem to be approximately in the ratios 9:10:8:8, difference between various fish species being not distinct.

As to relative fishing ability by base ports computed on the data in Table 15, vessels of 2A type scarcely differ between various base ports, though they are often attended by abnormality due to difference in fishing ground section (see Fig. 14). Fishing abilities of 1A and B vessels too do not vary to any serious extent between different base ports with exceptions of only a few cases (see Figs. 15 and 16). As regards fishing ability of C type vessel, comparison between various base ports turns out meaningless because of the greatness of mutual discrepancy of the fishing grounds they favor.

Thus, it may be said after all that excepting a few cases under strong effect due to disagreement in fishing ground, fishing ability of pair trawl fishery

does not seriously vary between different base ports, insofar as vessels of a definite type are concerned.

VI. Comparison of Fishing Ability between Otter Trawl and Pair Trawl Fisheries

In this chapter relative fishing abilities of otter trawl and pair trawl fisheries are treated in the aspect of fishing gear and further in that of habit of fish species to be caught.

First, to comparatively appraise the catches attained in a draught by otter trawl and pair trawl fisheries, respectively, the data in the "Catch Statistics of Trawl Fisheries in the East China and the Yellow Seas" for 1953 were submitted to the following sequence of calculations: Average catch per draught by fish species was calculated for otter trawlers as well as pair trawlers, taking all operated vessels into account. The time and place of fishing adopted as the object of calculation were such particular months as optimum catches at least of a fish species had been attained then by otter trawl fishery and such fishing ground sections as both otter trawl and pair trawl fisheries had there been more or less substantially rewarded, the fishing ground sections being in the present calculation so defined as to accord with their existing definition. Then, using the values of average monthly catch per draught thus obtained for otter trawl and pair trawl fisheries, respectively, geometric means of these values among the fishing ground sections concerned were calculated and adopted as standard catches per draught of various fish species per month and per fishing ground section. The reason why geometric means were adopted is to obtain such values as completely free as possible from peculiarities of each fishing ground section

Table 16. Ratio of average catch per draught by otter trawl fishery to that by pair trawl fishery shown by species of fish.

Notation of fish species	Co_T/Cp_T	$Co_T/Cp_T/1.57$	Notation of fish species	Co_T/Cp_T	$Co_T/Cp_T/1.57$
1	3.10	1.97	12	1.65	1.05
2	0.21	0.13	13	15.8	10.1
3	0.95	0.61	14	1.44	0.92
4	0.26	0.17	15	0.93	0.59
5	0.22	0.14	16	0.80	0.51
6	1.03	0.66	17	1.06	0.68
7	1.86	1.18	18	0.90	0.57
8	6.84	4.36	19	1.64	1.04
9	0.27	0.17	20	0.50	0.32
10	0.68	0.43	21	0.69	0.44
11	1.84	1.17	24	0.99	0.63

The numeral notations of fish species are the same as those shown in Table 6, and the Co_T and p_T represent values for average catch per draught by otter trawl fishery and pair trawl fishery, respectively.

such as those in frequency of trawling, density of fish distribution, etc. Further, using these geometric means, the ratios of average catch per draught of otter trawl fishery to that of pair trawl fishery were calculated for each fish species, the results being shown in Table 16.

Next, to comparatively appraise catches obtained from a definite sweep area by otter trawl and pair trawl fisheries, respectively, the areas swept in trawling were calculated from existing materials as follows: Assuming that in otter trawl fishery a net having wing tips at a distance of 25 m is drawn with a speed of 3.0 knots[2] for a duration of draught of 4.0 hours, sweep area per draught in this fishery amounts to $25\times1,852\times3\times4\fallingdotseq5.56\times10^5(m^2)$. As regards pair trawl fishing in which a net is drawn, as it is so in general, in each draught at a speed of 2.0 knots for a duration of 2.0 hours with wing tips mutually 50 m distant in first 1.7 hours, 40 m in middle 0.2 hours and 25 m in last 0.1 hour, sweep area per draught amounts to $(50\times1.7+40\times0.2+25\times0.1)\times1,852\times2\fallingdotseq3.54\times10^5(m^2)$. It may hence be said that the area swept in otter trawl fishery is 1.57 times as large as that in pair trawl fishery. As to the catch attained by sweeping a definite area, therefore, the attainment by otter trawl fishery relative to that by pair trawl should correspond to the values obtained by dividing the values for relative average catch per draught, which are given in Table 16, by 1.57. The results thus obtained are also shown in Table 16. As seen from the table, otter trawl is inferior to pair trawl in regard of fishing abilities for snapper, crimson sea bream, long tailed snapper, lizard fish, white croaker, butter fish and ray, though superior with regard to those for porgy, lage croaker and hairtail. Generally speaking, pair trawl fishery show higher fishing ability as compared with otter trawl fishery, so far as the data in this table concerned.

It should be noticed, however, that different types of fisheries are possible from commerical reason to concentrate their efforts each at catching a specified

Table 17. Monthly mean catch per draught by otter Trawl and pair trawl in 1951, '52 and '53. (Unit: Kg)

Month	Otter Trawl			Pair Trawl		
	'51	'52	'53	'51	'52	'53
Jan.	1,059	958	1,096	689	628	618
Feb.	747	1,236	910	709	679	597
Mar.	758	1,335	932	703	705	586
Apr.	630	857	712	599	655	533
May	614	735	570	512	632	524
Jun.	508	782	507	491	598	500
July	423	488	388	560	551	480
Aug.	470	505	451	650	546	541
Sept.	590	528	423	551	489	499
Oct.	610	546	608	597	592	566
Nov.	751	517	601	596	585	543
Dec.	755	837	591	596	601	535

fish species, also the data in Table 16 being thus likely attached by artifacts arising from this sort of commerical preference of fish species. Very low values in the table are thus possible to be mere reflections of that otter trawl was not operated for catching the species corresponding to these values. In order to draw an inference not commercially deformed, therefore, appraisal of fishing ability must be done also in another light of data for total catch or independent of particularized fish species. In this point of view, values of monthly total catch for otter trawling as well as those for pair trawling in 1951, '52 and '53, which are reproduced in Table 17, will now be referred to. Using the data in this table, monthly catch attainments by otter trawling are compared with those by pair

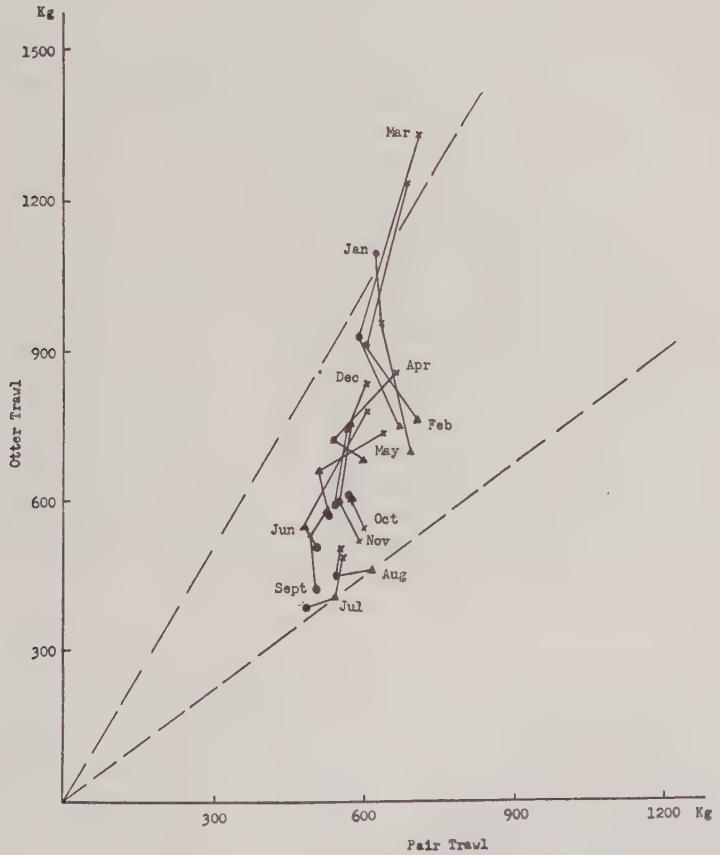

Fig. 17. Monthly comparison of fishing ability between otter trawler and pair trawler, where ▲, ×, ● stand for 1951, '52, '53, respectively.

trawling as shown in Fig. 17. From this illustration, it may be said that fishing ability of otter trawl is not greatly different from that of pair trawl, they being approximately in the ratio 11:10.

The illustration declares also that otter trawl is operated in comparison with pair trawl at a higher fishing ability in a period of from January to March and

at a lower ability in a period of from July to August. As for hairtail stock of Bokkai which occupies a large portion of total catch, the best fishing season falls in the former period. In July and August this stock migrates northward for spawning, going out of the object of otter trawl fishery. Schools becoming the object of otter trawl in this season, in turn, belong to a stock of coast of China and are distributed at a rather low density in a water layer remote so far from sea bottom that they cannot be reached by an otter trawl net. The eventual high fishing ability of otter trawl found in said season may hence be interpreted as a reflex of the conditions mentioned above. In pair trawl fishery, on the other hand, there is no such fish species as occupies a large portion of total catch. In summer, most of the fishes caught in commercial quantities by trawlings in the East China and the Yellow Seas become contracted in the area and elevated in the water layer of their distribution. For this reason catches by said two types of trawlings tend apparently to decrease in this season. However, pair trawl fishery in which a net having a mouth opened to a greater height is used as compared with otter trawl fishery is expected to less seriously suffer the reduction of fishing ability due to elevation of water layer of fish distribution. This expectation seems to be justified by the illustration of Fig. 17.

As already mentioned, fishing abilities of otter trawl and pair trawl appraised from catch per draught may be said to be approximately in the ratio 11: 10. However, if the situation that a draught in the former covers an area 1.57 times as large as the area swept in a draught of the latter is taken into account, catch attainments of these two types of trawlings in sweeping identical areas should be in the ratio 11/1.57:10, namely, 7:10. As to the height up to which net-mouth is kept opened in actual operation, values of 2.0 and 3.8 meters can be assigned to otter trawl and pair trawl, respectively, the values being thus in the ratio 5.3:10. The discrepancy between the above two ratios, 7:10 and 5.3:10, may have arisen not only from the differences in fishing gear, fishing method but from a grave subject that fish species are different according to whether they are the object of otter trawl fishery or that of pair trawl fishery.

VII. Conclusion

Existing data of the catch attinments by trawl fisheries in the East China and the Yellow Sea regions may be availed to form an estimate of fishing ability first after the data have been subjected to some revision in consideration of the actual circumstances of these fisheries. Indeed, all the data ever published, including the "Catch Statistics of Trawl Fisheries in the East China and Yellow Seas" issued by the Government relate to the catches attained under commerical intentions such as preference of particular sections of fishing ground. The author has tried in the present work to appraise fishing abilities of trawl fisheries in said sea regions on the data of catch he revised in the above viewpoint and somehow arrived at materials available for criticizing the peculialities of various factors governing the fishing abilities such as base port, vessel type, mode of fishing operation, etc. Whereas not a small cases were met with in which effects of artifact get out of hand especially in respect of the species of caught fishes, it is con-

sidered that the differences in fishing ability found in the other cases will be available for future improvement of trawl fisheries because of their pointing out the sources from which the differences are derived.

Acknowledgements

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THE CLASSIFICATION OF ENTEROCOCCI ON THE BASIS OF FERMENTATION AND NUTRITIONAL REQUIREMENTS

Susumu Horie

Recently enterococcal organisms, as pollution indices of waters and foods, have received considerable attention due to their superiority, as compared with coliform organisms, in indicating recent pollution by human and animal feces. Studies of the classification of enterococci have been made by Dible[1], Lancefield[2], Sherman et al.[3-8] and many other workers[9-18]. According to the 7th ed. of Bergey's manual[19], there exists an "enterococcus group" in the genus *Streptococcus*; the organisms belonging to this group are characterized by the ability to grow in broth at 10° and 45°C., in broth containing 6.5% NaCl, and in alkaline broth of pH 9.6. The enterococcus group is subdivided into two subgroups by the β-haemolytic property, i.e., a non-β-haemolytic subgroup including *Str. faecalis* and *Str. faecalis* var. *liquefaciens*, and a β-haemolytic subgroup consisting of *Str. faecalis* var. *zymogenes* and *Str. durans*.

The author investigated various physiological properties of a number of enterococcal strains isolated from human and animal feces, soils, waters and foods. From the results of these observations it was found: (1) that all of the above strains are non-β-haemolytic, (2) the description in Bergey's manual concerning the classification of the non-β-haemolytic enterococci is not suitable.

The present study revealed that the non-β-haemolytic enterococcal organisms can be classified into three types, clearly distinguished from each other by differences in fermentation of certain carbohydrates and in their nutritional requirements.

Experimental methods

Ability to grow at 10° and 45°C. A dextrose broth was used consisting of 1% peptone, 0.5% meat extract, 0.2% NaCl and 1% dextrose; growth was observed after incubation at 10°C. for 6 days or 45°C. for 48 hours.

Ability to grow in dextrose broth containing 6.5% NaCl, and in alkaline broth of pH 9.6. These media were prepared by modifying the composition of the dextrose broth mentioned above in respect to the pH value or the NaCl concentration; the growth was observed after incubation at 37°C. for 48 hours.

Test of β-haemolysis. The blood agar for the test of β-haemolysis was prepared using 5% horse blood.

Liquefaction of gelatine. A gelatine medium was used consisting of 1.5% peptone, 0.5% meat extract, 0.5% yeast extract, 0.5% NaCl, 0.1% dextrose and 15% gelatine; incubation was at 22°C. for 20 days.

Fermentation of carbohydrates. A test media was used containing 1% peptone, 0.3% yeast extract, 0.5% NaCl, 0.0024% brom thymol blue and 1% of each carbohydrate to be tested, and the production of acid after incubation for 48

hours at 37°C. was determined by the change in color of the media.

Determination of sensitivities to certain antibiotics. Streptomycin, chlortetracycline and penicillin were used in these experiments. Dextrose agar plates consisting of 1% peptone, 1% meat extract, 0.2% NaCl, 0.5% dextrose, 2% agar and varying concentrations of the antibiotic to be tested were used, and the minimum growth-inhibiting concentration of the antibiotic was determined after incubation at 37°C. for 18 hours. The reaction of the medium containing streptomycin was adjusted to a pH of 7.0, and in the case of chlortetracycline and penicillin to a pH of 6.5.

Nutritional requirements. For the amino acid requirement test a basal medium similar to the uniform medium for amino acid assay according to Henderson and Snell[20] was used. The composition of the medium is shown in Table 1.

Table 1. Composition of basal medium for amino acid requirement test.

Component	Amount in 100 ml.	Component	Amount in 100 ml
Dextrose	2 g	Biotin	1 γ
Sodium citrate	2 〃	Folic acid	1 〃
〃 acetate	0.1 g	*dl*-Alanine	100mg
NH_4Cl	0.3 〃	*dl*-Aspartic acid	100 〃
K_2HPO_4	0.5 〃	*l*-Glutamic acid	100 〃
$MgSO_4\ 7H_2O$	80mg	*l*-Arginine·HCl	20 〃
$FeSO_4 \cdot 7H_2O$	4 〃	*l*-Lysine·HCl	20 〃
NaCl	4 〃	*dl*-Histidine·HCl	20 〃
$MnSO_4 \cdot 4H_2O$	16 〃	*dl*-Isoleucine	20 〃
Adenine sulfate·$2H_2O$	1 〃	*dl*-Leucine	20 〃
Guanine hydrochloride·$2H_2O$	1 〃	*dl*-Methionine	20 〃
Uracil	1 〃	*l*-phenylalanine	10 〃
Xanthine	1 〃	*dl*-Threonine	20 〃
Thiamine hydrochloride	100 γ	*dl*-Tyrosine	20 〃
Riboflavin	100 〃	*dl*-Valine	20 〃
Pyridoxal·HCl	20 〃	*dl*-Tryptophane	20 〃
Ca pantothenate	100 〃	*l*-Cystine	10 〃
Nicotinic acid	100 〃	*dl*-Serine	20 〃
p-Aminobenzoic acid	20 〃	Glycine	10 〃

The final solution was adjusted to pH 6.8.

In the case of the vitamin requirement test, 0.5% acid hydrolyzed, vitamin free casein (Bacto-Casamino Acid) was substituted for all of the amino acids shown in Table 1 other than cystine and tryptophane. Inocula were prepared by three serial transfers in the same basal medium at 24 hour intervals, and the washing of cells prior to inoculation was omitted except in the case of preliminary experiments. The medium being tested was inoculated, as a rule, with a fine wire needle, and the degree of growth after a 48 hour incubation was observed.

Experimental results

Isolation of enterococcal strains

By using the dextrose azide-ethyl violet azide broth method according to Litsky et al.[21], 420 strains were isolated from human and animal feces, soils, waters and foods. These strains were subjected to the following tests: (1) a microscopic examination using the Gram stain method, (2) ability to grow at 10° and 45°C., in broth containing 6.5% NaCl, in alkaline broth of pH 9.6, and in 40% bile blood agar, (3) β-haemolysis, (4) resistance to temperatures of 60°C. for 30 minutes, (5) liquefaction of gelatine, (6) growth in 0.1% methylen blue milk, and (7) the fermentation of mannitol and sorbitol.

The results of these investigations showed that 313 of the 420 strains were gram-positive coccal organisms, and they were able to grow at 10° and 45°C., in 6.5% NaCl broth, at pH 9.6 and in 40% bile blood agar, and can be regarded as enterococcal organisms. In these strains no β-haemolytic organisms were found. A few strains were unable to grow in 0.1% methylene blue milk, and a considerable number could not survive 60°C. for 30 minutes.

Fermentation of carbohydrates

Among the isolated strains 137 were used in fermentation tests of eleven

Table 2. Frequency of strains differentiated in fermentative characteristics.

		Type I							Type II	Type III						Atypical strain				Total
	Dextrose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
	Lactose	+	+	+	+	+	+	+	+	+	+	+	−	−	+	+	+	+	+	
	Maltose	+	+	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+	
	Sucrose	+	+	+	+	+	+	−	+	+	+	+	+	+	−	+	+	−	+	
	Mannitol	+	+	+	+	+	+	+	−	+	+	+	+	+	+	+	−	−	+	
	Sorbitol	−	−	−	−	−	−	−	−	+	+	+	+	+	+	−	−	−	+	
	Glycerol	−	−	−	−	−	−	−	−	+	+	+	+	+	+	−	−	+	−	
	Arabinose	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	+	−	−	
	Raffinose	−	+	−	+	−	+	−	−	−	−	+	−	−	−	+	+	−	−	
	Xylose	−	−	−	−	+	+	−	−	−	−	−	−	−	−	+	−	−	−	
	Rhamnose	+	+	−	−	−	−	−	−	−	+	+	+	−	+	−	−	−	+	
Source	Human feces	5	8	6	4	2	1	1	14	11	2				1			1	1	1	58
	Animal feces	2	2				1		17	2	3				2						29
	Water		2		1		1		3	5	1					1	1				15
	Soil			1	1				7	3	4	1									17
	Food		2	2					5		3	2	2	2							18
	Total	7	14	9	6	2	3	1	46	21	13	3	2	2	3	1	2	1	1	137
		42							46	44						5				

kinds of carbohydrate. All of the strains fermented dextrose and maltose. Almost all strains fermented lactose and sucrose. Although ability to ferment the other seven kinds of carbohydrate varied in different strains, it was found that, according to the result of the fermentation tests of mannitol, sorbitol, glycerol and arabinose, these organisms can be divided into three distinct types: I, II and III. The frequencies of strains differentiated by fermentative characteristics are shown in Table 2.

One hundred and thirty-two strains, with the exception of five strains which showed atypical fermentation, were included in the three types mentioned above. According to Bergey's manual all of these strains should belong to either *Str. faecalis* or *Str. faecalis* var. *liquefaciens*. The latter is distinguished from the former by the ability to liquefy gelatine. The results of the present investigation revealed that all of the strains with the ability to liquefy gelatine belong to Type III. The results of fermentation tests on thirteen strains presented from the American Type Culture Collection are shown in Table 3. Among the seven

Table 3. Fermentative properties of enterococcal strains of ATCC.

Strain		Dextrose	Lactose	Maltose	Sucrose	Mannitol	Sorbitol	Glycerol	Arabinose	Raffinose	Xylose	Rhamnose	Type
Str. faecalis	ATCC 8043	+	+	+	+	−	−	−	−	−	−	−	II
Str. faecalis	ATCC 10541	+	+	+	+	−	−	−	−	−	−	−	II
Str. liquefaciens	ATCC 4532	+	+	+	+	+	+	+	−	−	−	−	III
Str. zymogenes	ATCC 10100	+	+	+	+	+	+	+	−	−	−	−	III
Str. durans	ATCC 9810	+	+	+	−	−	−	−	−	−	−	−	II
Str. faecalis	ATCC 9790	+	+	+	+	−	−	−	−	−	−	−	II
Str. faecalis	ATCC 8022	+	+	+	+	−	−	−	−	−	−	−	II
Str. faecalis	ATCC 6569	+	+	+	+	+	−	−	+	−	−	−	I
Str. faecalis	ATCC 6057	+	+	+	−	+	−	−	+	−	−	−	I
Str. faecalis	ATCC 4835	+	−	+	+	+	+	+	−	−	−	−	III
Str. zymogenes	ATCC 6054	+	+	+	+	+	+	+	−	−	−	−	III
Str. durans	ATCC 423	+	+	+	+	−	−	−	−	−	−	−	II
Str. durans	ATCC 6056	+	+	+	−	−	−	−	−	−	−	−	II

strains of *Str. faecalis*, four belonged to Type II, two to Type I, and one to Type III. One strain of *Str. liquefaciens* and two strains of *Str. zymogenes* belonged to Type III.

Relationship between the nutritional requirements and types of enterococcal organisms

Investigations were carried out to determine the differences in nutritional requirements of the various enterococcal types. It was shown by preliminary experiments that some strains, representing the three types, together required three kinds of vitamins, pantothenic acid, nicotinic acid and biotin, and nine

amino acids: glutamic, arginine, histidine, isoleucine, leucine, methionine, valine, tryptophane and glycine. On the other hand, it was found that significant differences exist in the requirements of riboflavin, folic acid and threonine among the three types of enterococci. Nutritional requirements of 114 strains belonging to Type I–III are shown in Table 4.

Table 4. Relationship between nutritional requirements and the types of enterococci.

Nutritional requirement			Number of strains tested		
Riboflavin	Folic acid	Threonine	Type I	Type II	Type III
+	±	+	56		
−	−	−	1		
−	±	+	5	2	
+	+	+		1	
−	+	+		18	
−	−	+		1	
+	−	+		1	1
+	−	−			28
Total			62	23	29
			114		

Type I organisms require both riboflavin and threonine, while the absence of folic acid in the medium suppreses the growth of this type. Type II organisms require folic acid and threonine, but not riboflavin. On the contrary, Type III organisms require riboflavin, but not folic acid and threonine.

Relationship between types of enterococci and their sensitivities to some antibiotics

Sensitivities of 134 strains to streptomycin, chlortetracycline and penicillin were determined, and the result are shown in Table 5. In was found that Type III organisms are generally more resistant to streptomycin and chlortetracycline than the other two types.

Table 5. Growth-inhibitory action of antibiotics on enterococcal strains of different types.

Strains		Minimum growth-inhibiting concentration of antibiotics													
		Streptomycin (γ per ml)				Chlortetracycline (γ per ml)				Penicillin (u per ml)					
Type	Number	250	100	50	25	5.0	2.5	1.0	<1.0	5	2.5	1.0	0.5	0.25	<0.25
Type I	44	0	5	5	34	2	6	36	0	12	20	3	5	2	2
Type II	45	0	3	24	18	0	7	30	8	3	8	13	13	5	3
Type III	45	6	37	2	0	2	38	5	0	15	28	2	0	0	0

Figure represents the number of strains.

Type distribution of enterococcal organisms from various sources

Independent of the above discussed experiments, a large number of enterococcal strains have been collected from various sources. The type distribution of the enterococcal organisms was observed; the results are shown in Table 6.

Table 6. Type distribution of enterococcal organisms in various sources.

Source	Type			Irregular type					Total
	I	II	III	I	II	III	IV	V	
Human feces	69	10	9	3	1				92
Raw fishes and shellfishes	18	10	35	1	1	1	5		71
Frozen foods	33	10	17		1		2		63
Ice-creams	22	4	10		2			1	39
Well waters	6	3	4						13
Coastal bathing waters	7	3	2	2					14
Water of swimming pool			1						1
River waters	1	1							2
Sewages	5	3		1					9
Total Numbers	161	44	78	7	5	1	7	1	304
Total %	53.0	14.5	25.7	2.3	1.6	0.3	2.3	0.3	
	93.2			6.8					

Figure represents the number of strains.

Among 304 strains isolated in this experiment, 283 strains (93.2%) were found to be classified in the three types mentioned above: 161 strains (53.0%) belonged to Type I, 44 strains (14.5%) to Type II, 78 strains (25.7%) to Type III. In general, type I organisms were found to be most predominant.

Fermentative characteristics and nutritional requirements of each type of

Table 7. The relationship between the enterococcal types established in this study and the species according to Bergey's manual.

Type	Fermentation				Nutritional requirement			Liquefaction of gelatine	Classification according to Bergey's manual
	Mannitol	Sorbitol	Glycerol	Arabinose	Riboflavin	Folic acid	Threonine		
I	+	−	−	+	+	±	+	−	
II	−	−	−	−	−	+	+	−	*Str. faecalis*
III	+	+	+	−	+	−	−	−	
								+	[1] *Str. faecalis* var. *liquefaciens*

enterococcus group, and the relationship between the enterococcal types mentioned above and the species according to Bergey's manual are shown in Table 7.

Discussion

Althought a number of enterococcal strains were isolated from human and animal feces, soils, waters and foods, all of them were non-β-haemolytic strains. From the experimental results presented above, it was revealed that when enterococcal organisms are treated as pollution indices, β-haemolytic species, according to Bergey's manual *Str. faecalis* var. *zymogenes* and *Str. durans*, are negligible from the practical point of view, while non-β-haemolytic species, *Str. faecalis* and *Str. faecalis* var. *liquefaciens*, are significant. *Str. faecalis* var. *liquefaciens* is distinguished from *Str. faecalis* only by proteolytic properties, e.g., the liquefaction of gelatine. On the other hand, in this study it was found that the non-β-haemolytic organisms can be classified into three distinct types by the differences in fermentation of certain carbohydrates and their nutritional requirements. *Str. faecalis* described in Bergey's manual corresponds to Type III mentioned above in this study, and *Str. faecium*, according to Orla-Jensen, corresponds to Type I. Although from certain points of view Type II ought to be included in *Str. faecalis*, due to the failure of Type II to ferment mannitol, sorbitol or glycerol, there is definite disagreement. Gelatine-liquefying organisms were not found in Type I or II, but all of them belonged to Type III.

The detection of the fact that the nutritional requirements of enterococcal organisms correlate with the type to which they belong increases the significance of this classification method.

The result of this study show that Type I organisms are found most frequently in human feces and other polluted materials, therefore, this type may be most important when enterococcal organisms are treated as pollution indices. On the other hand, in the case of animal feces Type II organisms have been isolated more frequently than the other types. Although some enterococcal organisms were found in soils and waters in mountainous districts which may not have been contaminated by human activity, all strains encountered were gelatline-liquefying ones belonging to Type III.

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Summary

A number of enterococcal organisms have been isolated from human and animal feces, soils, waters and foods. All of the strains isolated were found to be non-β-haemolytic, and it was revealed that these organisms can be classified into three distinct types: I, II and III, using marked differences in fermentation of certain carbohydrates, mannitol, sorbitol, glycerol and arabinose, and in the nutritional requirements of riboflavin, folic acid and threonine. Since the classification of enterococcal organisms as pollution indices according to Bergey's manual appears to be unsatisfactory, the method presented in this study may be more suitable.

Considering the fact that Type I organisms are found most frequently in human feces and in other polluted materials, this type can be regarded as the most significant one from the viewpoint of pullution indices.

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THE DISCOLORATION OF FATTY MATERIALS BY GAMMA RAY IRRADIATION—PRELIMINARY REPORT

Ikunosuke Okada, Takeaki Kikuchi, Toshiyuki Hirano and Tadao Kitano

The sterilization of food by gamma ray irradiation would be a most desirable method of preserving fresh food, but unfortunately the changes in flavour and color are intense and unpleasant. Therefore before gamma ray sterilization can be put to practical use, it is necessary to find a solution to the problem of the production of undesirable colors and flavours.

The discoloration of food by gamma ray irradiation resembles the browning which is often observed in the long-term storage of food.

The browning of sugar solution by gamma ray irradiation, has already been investigated.[1-7] However, sterilization of sea foods, which contain many fatty materials, it is important to investigate the discoloration of fatty materials by gamma ray irradiation. Some studies have already been made of the discoloration of fat and oil,[8-10] but not of mixtures of fatty and other materials.

In this paper the authors examined experimentally the discoloration of fatty materials in the presence of amino acids.

Experimental Data

It is desirable to make a uniform mixture of fatty material and amino acid for the estimation of the discoloration of fatty materials; to achieve this result alcohol and other organic solvents should be used.

In the use of organic solvent, it is afraid that the discoloration depends upon the reaction of amino acid and carbonyl compound which is produced in the organic solvent during the gamma ray irradiation.

Here, the mixture of aquatic solution of amino acid and fatty material is used for the experiment instead of the uniform mixture of fatty material and amino acid in organic solvent.

1) Discoloration of oleic acid in the presence of several amino acids:

The oleic acid used for this experiment was repurified G.R. reagent and the iodine number was 89.0. On the other hand, 15 kinds of amino acid in the quality of G.R. were DL-alanine, L-arginine monohydrochloride, L-asparatic acid, glutamic acid (sodium salt), glycine, L-histidine monohydrochloride monohydrate, L-hydroxyproline, L-leucine, L-lysine monohydrochloride, DL-methionine, L-phenylalanine, L-proline, L-serine, DL-threonine and DL-valine.

A 0.5% solution of each amino acid in water was prepared and added to an equal volume of oleic acid, the mixture was shaken violently by hand in a test tube, and then exposed to gamma rays. Gamma ray irradiation was applied in doses of 5×10^5, 2×10^6 and 5×10^6r. for each mixture. The source of the gamma ray irradiation was 1 kc of cobalt 60 in our laboratory.

After irradiation the discoloration of the mixture was observed, then the

Table 1. The discoloration of oleic acid by gamma ray irradiation in the presence of amino acid solution.
U, upper layer of the mixture (oleic acid)
L, lower layer of the mixture (amino acid solution)

Day	0						10						18						48					
Dose (r)	Control		2×10^6		5×10^6		Control		2×10^6		5×10^6		Control		2×10^6		5×10^6		Control		2×10^6		5×10^6	
Amino acid. Layer	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
Water-cont.	−	−	−	−	−	−	±	−	+	−	##	−	±	−	##	−	±	−	±	−	±	−	±	−
Alanine	−	−	±	−	±	−	±	−	+	−	##	−	+	−	###	−	###	−	##	−	###	−	###	−
Arginine	−	−	±	−	±	−	±	−	+	−	##	−	±	−	##	−	###	−	+	−	##	±	###	−
Asparatic acid	−	−	±	−	±	−	±	−	+	−	##	−	±	−	##	−	##	−	+	−	##	−	##	−
Glutamic acid	−	−	±	−	±	−	±	−	+	−	##	−	+	−	###	−	###	−	+	−	##	−	##	−
Glycine	−	−	±	−	±	−	±	−	+	−	##	−	+	−	###	−	###	−	+	−	##	±	###	±
Histidine	−	−	±	+	+	##	±	−	##	##	###	###	+	−	###	###	###	###	+	−	##	##	###	###
Hydroxyproline	−	−	±	−	±	±	±	−	+	+	##	+	+	−	###	##	###	##	##	−	##	##	###	##
Leucine	−	−	±	−	+	−	±	−	+	−	##	−	+	−	###	−	###	−	##	−	##	−	###	−
Lysine	−	−	±	−	±	−	±	−	+	−	##	−	+	−	##	±	###	±	##	−	##	+	###	+
Methionine	−	−	±	−	+	+	±	−	##	−	###	+	+	−	###	−	###	±	+	−	###	−	###	+
Phenylalanine	−	−	±	−	±	−	±	−	+	−	##	−	+	−	###	−	###	−	+	−	##	−	###	±
Proline	−	−	±	−	±	−	±	−	+	−	##	−	+	−	##	−	###	−	##	−	##	−	###	±
Serine	−	−	±	±	+	+	±	−	###	+	###	+	±	−	###	+	###	+	+	−	##	±	###	+
Threonine	−	−	±	±	+	+	±	−	###	+	###	+	±	−	###	+	###	±	##	−	##	−	###	+
Valine	−	−	±	−	±	−	±	−	+	−	##	−	+	−	##	−	###	−	##	−	##	−	###	−

The degree of discoloration is presented in the symbol of −, + etc. compared with the color of $K_2Cr_2O_7$ solution.

A symbol of ± presents a yellow color of $K_2Cr_2O_7$ solution in the concentration of N/10000, and +, N/5000; #, 3N/10000; ##, N/2000; ###, N/1000; ####, N/500 respectively.

irradiated samples and unirradiated controls were incubated at 37°C and the observation of discoloration continued. The results are presented in Table 1.

Immediately after irradiation the mixture turned slightly yellow; the unirradiated control did not change. The discoloration of oleic acid was different with the kind of amino acid that was present in the mixture. A slightly yellow color was observed in oleic acid containing histidine, leucine, methionine, serine, and threonine, and others were unchanged.

A discoloration of oleic acid developed in all cases during the storage at 37°C; the degree of discoloration was distinct in the presence of amino acids such as histidine, leucine, methionine, serine and threonine.

In this experiment the mixed solution was separated into two layers after irradiation i.e., oleic acid and amino acid solutions. The degree of discoloration in each layer differed with each amino acid present in the mixture.

The discoloration of oleic acid was already described. The amino acid solution i.e., the lower layer of the mixture, was also discolored by gamma rays; a yellow color was observed in histidine and to a lesser extent in hydroxyproline, methionine, serine and threonine.

The coloring that occurred in the layer of histidine solution was more distinct than in the layer of oleic acid; the coloring in other amino acids was less pronounced than the coloring of oleic acid.

2) Discoloration of oleic acid in the presence of various concentrations of amino acid:

The relation between the coloring and the concentration of amino acid was examined.

The aqueous solutions of 0.5, 1.0 and 5.0% of cysteine and histidine were prepared respectively, added to equal volumes of oleic acid, and shaken violently. The mixtures were irradiated with 5×10^5, 2×10^6 and 5×10^6r., the coloring was observed as in the previous experiment. The results are presented in Table 2.

Immediately after irradiation oleic acid mixed with 0.5 and 1.0% solutions of cysteine did not shown any change of color, but irradiated oleic acid mixed with a 5.0% cysteine solution gave a distinct yellow color. After irradiation and incubation for 8 days at 37°C, a yellow color generally developed; extreme coloration was found both in the presence of high concentrations of amino acid and in high dosages of gamma ray irradiation. The discoloration of histidine was more distinct than cysteine, and the yellow color was clearly observed even immediately after irradiation; incubation, as described above, caused further coloration to develop.

3) Discoloration of fatty materials in the presence of several amino acids:

The experiments mentioned above were conducted with oleic acid only; further experiments were conducted with stearic acid, oleic acid, fin whale oil and soybean oil.

Seven kinds of amino acids were used for these experiments because these amino acids gave a positive result for coloring in the previous experiments. The objective was to dated different discoloration among the saturated fatty acids, unsaturated fatty acids, animal oil and vegetable oil mixed with the amino acids. In these experiments it was necessary to use ethyl ether for the solvent of fatty

Table 2. The discoloration of oleic acid by gamma ray irradiation in the presence of different concentration of amino acid.
U, upper layer of the mixture (oleic acid)
L, lower layer of the mixture (amino acid solution)

Amino acid	Day	0								8								35							
	Dose (r)	Control		5×10^5		2×10^6		5×10^6		Control		5×10^5		2×10^6		5×10^6		Control		5×10^5		2×10^6		5×10^6	
	Layer	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
Histidine	0.5%	−	−	−	+	−	##	+	##	±	−	+	+	##	##	##	##	+	−	+	+	##	##	##	##
〃	1.0	−	−	−	+	−	##	+	##	±	−	+	+	##	##	##	##	+	−	##	+	##	##	##	##
〃	5.0	−	−	−	+	−	##	##	##	+	−	+	+	##	##	##	##	##	−	##	##	##	##	##	##
Cysteine	0.5	−	−	−	−	−	−	−	−	+	−	+	−	##	−	##	−	##	−	##	−	##	−	##	+
〃	1.0	−	−	−	−	−	−	−	−	+	−	##	−	##	−	##	−	##	−	##	−	##	−	##	+
〃	5.0	−	−	−	−	−	−	+	−	##	−	##	−	##	−	##	−	##	−	##	−	##	−	##	−

Table 3. The discoloration of fatty materials by gamma ray irradiation in the presence of several amino acids.
U, upper layer of the mixture (fatty materials)
L, lower layer of the mixture (amino acid solution)

Day	0															
Fatty material	Stearic acid				Oleic acid				Fin whale oil				Soy bean oil			
Dose (r)	Control		5×10^6		Control		5×10^6		Control		5×10^6		Control		5×10^6	
Amino acid / Layer	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
Cysteine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Glutamic acid	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Histidine	−	−	−	+	−	−	−	+	−	−	−	+	−	−	−	+
Methionine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Hydroxyproline	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Serine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Threonine	−	−	−	±	−	−	−	±	−	−	−	±	−	−	−	±
Day	8															
Cysteine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Glutamic acid	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Histidine	−	−	−	##	−	−	−	##	−	−	−	##	−	−	−	##
Methionine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Hydroxyproline	−	−	±	−	−	−	±	−	−	−	±	−	−	+	−	±
Serine	−	−	−	−	−	−	−	±	−	−	−	±	−	−	−	−
Threonine	−	−	−	+	−	−	−	##	−	−	−	##	−	−	−	−
Day	35															
Cysteine	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Glutamic acid	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Histidine	−	−	−	##	−	−	−	##	−	−	−	##	−	−	−	##
Methionine	−	−	−	−	−	−	−	−	−	−	+	+	−	−	−	−
Hydroxyproline	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+
Serine	−	−	−	−	−	−	−	±	−	−	−	±	−	−	−	−
Threonine	−	−	−	+	−	−	−	##	−	−	−	##	−	−	·	±

materials, because solid stearic acid is not soluble in water. The solutions of 10% of stearic acid, oleic acid, fin whale oil and soybean oil in ethyl ether were prepared respectively and added to equal volumes of 0.5% solution of amino acid.

The mixed solution was subjected to 5×10^6r. of gamma irradiation, and the discoloration was observed. The results are presented in Table 3. In this experiment no definite discoloration was found in fatty materials. It is probable that the fatty material was of so low a concentration that the fatty material did not shown any visible discoloration. But in the solution of amino acid, i.e., the lower layer of the mixture, some of the amino acids turned yellow after the irradiation and further developed the discoloration after being left at room temperature. The yellow discoloration was more distinct when serine and threonine were irradiated with oleic acid or fin whale oil than when they were irradiated with stearic acid.

The results seem to indicate a different discoloration of the amino acid with different kinds of coexistent fatty material.

4) Discoloration of fatty materials in the presence of histidine, histamine and ammonia:

As described above, fatty materials developed a yellow discoloration when they were exposed to gamma rays in the presence of amino acid. It seems that the occurrence of discoloration is due to the reaction of amino acid and carbonyl compound which is produced in fatty materials during the gamma ray irradiation. Accordingly, all amino acids should give a similar discoloration when subjected to gamma irradiation in the presence of fatty materials, but in fact this is not so, and distinct discoloration occurs only in the presence of certain amino acids such as histidine. The phenomenon can not be explained simply by the reaction of amino acid and carbonyl compound.

The authors conducted further experiments in an attempt to clarify the phenomenon in the light of some decomposition product of amino acid. The following mixtures were tested: oleic acid and a 1% solution of histidine, oleic acid and a 1% solution of histamine, and oleic acid and a 0.1% solution of ammonia. These mixtures were exposed to gamma ray irradiation of 5×10^5, 2×10^6, and 5×10^6r. then incubated at 37°C. The discoloration results are presented in Table 4. Although it was not a qualitative estimation, the same discoloration was observed both in histidine and histamine solutions whether or not they were mixed with oleic acid. The result indicate that the histamine, which is considered to be a decomposition product of histidine, is the original substance discoloring the oleic acid and the mother histidine solution.

The discoloration of the mixture of fatty material and amino acid may be caused in part by the discoloration of amino acids themselves, since it is possible to develop a yellow color in fatty materials from the coloring materials produced by gamma ray irradiation of an amino acid solution.

The discoloration of amino acid by gamma rays may occur from the reaction of amino acid and carbonyl compound, which is produced in the amino acid solution itself.

It was also ascertained that the ammonia, which is produced in the deamination of amino acid, was also a discoloring agent in the mixture of oleic acid

Table 4. The discoloration of oleic acid by gamma ray irradiation in the presence of histidine, histamine and ammonia.
U, upper layer of the mixture (oleic acid)
L, lower layer of the mixture (amino acid)

Day	0								32							
Dose (r)	Control		5×10^5		2×10^6		5×10^6		Control		5×10^5		2×10^6		5×10^6	
Material \ Layer	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
Oleic acid + water	−	−	−	−	−	−	−	−	±	−	±	−	±	−	±	−
Oleic acid + 0.1%, ammonia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Oleic acid + 1%, histidine	−	+	−	+	±	++	+	++	±	+	±	++	±	+++	+	+++
Oleic acid + 1%, histamine	−	+	−	+	−	++	+	++	±	+	±	+	±	++	+	+++
0.1%, ammonia	−		−		−		−		−		−		−		−	
1%, histidine	−		−		±		++		−		±		++		+++	
1%, histamine	−		−		−		+		±		±		±		+++	

and amino acid, or in the amino acid solution, although it is already known that the fatty materials are discolored in the presence of ammonia.

In conclusion, the discoloration of fatty materials in the presence of amino acid is due to the reaction of amino acid and carbonyl compound which is produced in fatty materials, and is promoted in the presence of ammonia. In the discoloration of an amino acid solution the same reaction occurred in the amino acid and carbonyl compound that is produced in the amino acid itself.

The present studies clarified that the discoloration of fatty materials by gamma ray irradiation occurs strongly in the presence of amino acid, and it is suggested that the occurrence of the discoloration in sea foods during gamma ray sterilization may result from the same mechanism. However, the experimental conditions were not strictly controlled in this study; further studies under more controlled conditions and including the investigated of the detailed mechanism of the discoloration are now being conducted. The results will be report in a latter paper.

Summary

1) Several kinds of mixtures of fatty materials and amino acids were exposed to gamma ray irradiation and observed for discoloration. The discoloration of fatty materials varied in the presence of amino acids.

2) A distinct discoloration of oleic acid was found in the presence of certain amino acids such as histidine, methionine, serine and threonine. The discoloration was enhanced by incubation at 37°C.

3) The degree of the discoloration of oleic acid was extremely strong in high concentration of coexistent amino acid, and with a high dose of gamma ray irradiation.

4) Some of the amino acids were also discolored by the gamma ray irradiation; discoloration increased on allowing the solutions to stand. A distinct yellow was observed in histidine and a slight yellow color was observed in methionine, serine and threonine immediately after irradiation. Extreme discoloration was found in histidine and hydroxyproline after incubating for 48 days at 37°C.

5) Comparative observation were made for the discoloration of stearic acid, oleic acid, fin whale oil and soybean oil in the presence of several amino acids; various degree of discoloration were observed.

6) The discoloration of oleic acid was tested for some decomposition product of amino acid, histamine and ammonia, and ascertained that the histamine was a discoloring agent for oleic acid.

The study was supported in part by a Grant in Aid for Departmental Scientific Research from the Ministry of Education which the offers their hearty thanks.

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EFFECTS OF GAMMA IRRADIATION ON THE CAN MATERIALS AND VARIOUS CANNED FOODS

Toshiyuki Hirano, Takeaki Kikuchi and Ikunosuke Okada

At present, the utilization of ionizing irradiation for sterilization and preservation of foods is generally recognized to be undesirable for modern industrial application owing to the problems of economy and safety of irradiated foods. It is expected that in the future irradiation will be possible to supplement canning and refrigeration, today's preservative processes of foods.

If irradiation becomes commercially practicable for food preservation, it will be required that the most suitable packages are selected to prevent bacterial contamination after irradiation. Furthermore, it will be also necessary to known the chemical and physical stablility or lability of the casing and packaging materials of food during irradiation and storage. Presently, plastic films and cellophanes are used as excellent casings for all kinds of foods, and the studies of irradiation on their casings for ham and sausage have been partly reported.[1-3]

In previous studies on the effect of gamma irradiation on canned mandarin oranges, swelling of the can was observed at a dose level of 2.0×10^6r, and H_2 and CO_2 were acertained as the components of gases by gas chromatography. Studies concerned with the behavior of irradiated and sterilized canned foods in storage are hardly known. Therefore, the effects of gamma irradiation on the can materials and on various canned foods was investigated.

Experimental

In the present study, the following subjects were involved:

(A) The organoleptic and ferroxyl tests of gamma irradiated canned foods and can materials.

(B) Irradiation effect on can materials and the constituents of canned foods.

(C) The polarographic estimation on the metals dissolved in can contents during gamma irradiation.

Samples for Irradiation

The kinds of canned foods used for experiment A are shown in Table 1. Interior surface of these cans were coated with lacquer, C-enamel or uncoated. The pocket typed cans coated or uncoated were employed for experiments B and C as shown in Table 1.

In the experiment B, common salt, sugar, soy sauce and citric acid as the typical constituents of canned foods were used. Concentrations of 2 per cent of common salt, and 17.5 per cent of sugar or 0.3 per cent of citric acid were prepared similar to be contained in boiled canned food in the former and in canned mandarin oranges in the latter. Besides, 5 per cent of common salt and 1 per cent of citric acid were examined. Each of these were packed in the pocked typed can after exhausting and were supplied for irradiation.

Table 1. Canned foods and other samples tested for irradiation and properties of their can materials.

Division	No.	Variety of samples	Can-made mark	Designation	Interior coating of cans			Remark
					Lid plate	Bottom plate	Body plate	
	1	Boiled Mackerel	0710	ET #4 tall	W or E	E	E	Products at Numazu Laboratory of Tokyo Univ. of Fish.
	2	Seasoned Tuna	0715	ET #2 flat	F	F	F	
	3	Smoked Tuna in oil	0721	ET #2 tuna	F	F	F	
Exp A.	4	Mandarin Orange in syrup	0215	HD #5 tall	F	F	W	Marketing goods
	5	Sweetcorn (creamed)	9007	ET #4 tall	E	E	E	
	6	Seasoned Whale	8515	ET #6 tall	F	F	F	
	7	Smoked Oyster in oil	8424	ET #3 B square	W	W	W	
	8	Boiled Salmon	7704	ET #3 flat	W	W	W	
	9	0.3% citric acid		ET #4 pocket	W	W	W	
	10	17.5% sugar (glucoss)		〃	W	W	W	
	11	Soy sauce		〃	W	W	W	
	12	2% common salt (sodium chloride)		〃	W	W	W	
Exp. B	13	17.5% sugar (glucose)		〃	F	F	F	Packed after exhausting
	14	〃		〃	W	W	W	
	15	5% common salt (sodium chloride)		〃	F	F	F	
	16	〃		〃	W	W	W	
	17	1% citric acid		〃	F	F	F	
	18	〃		〃	W	W	W	
Exp. C	19	5% common salt (sodium chloride)		ET #4 pocket	W	W	W	Packed in the air
	20	〃		〃	W	W	W	Packed after exhausting
	21	〃		〃	F	F	F	In the air
	22	dist. water		〃	W	W	W	In the air
	23	1% citric acid		〃	W	W	W	After exhausting
	24	〃		〃	F	F	F	After exhausting

ET: Electrolytic tin-plate, HD: Hot dipped tin-plate, #: Number, W: White (uncoated), E: C-enamel, F: Lacquer.

In experiment C, two kinds of solutions of 5 per cent common salt and 1 per cent citric acid were packed in pocket typed cans and irradiated under several conditions, with the expectation of damage of can materials by irradiation.

Method of Gamma Irradiation

Irradiation doses for this study were 5.0×10^5r and 2.0×10^6r, which are generally regarded as sufficient doses for pasteurization and sterilization respectively. The averaged dose rate of 6.0×10^4 roentgen per hour was employed for this irradiation from 1000 curies of Cobalt 60 at room temperature.

Method of Analysis

Organoleptic observation of canned foods was carried out for off-flavor, color and odor immediately after irradiation.

The irradiation damage of the tin-plate of the can materials was estimated by the ferroxyl test described in the Japanese Industrial Standard.[4] The method of determination was as follows: 10 g. of potassium ferricyanide, 10 g. of potassium ferrocyanide and 60 g. of sodium chloride were dissolved in 1 liter of dist-water as a detecting color reagent. For this analysis, the filter paper was dipped in the above reagent and placed in contact with the interior surface of the can which had been previously cleaned with ether and alcohol to remove any oily material. After being in contact for 30 minutes, the testing paper was torn off from the can and washed with water, then dried in the air. Detection of blue color prints on the paper were observed organoleptically.

The qualitative determination of metals dissolved in the irradiated can was carried out by polarographic method.[5] The test solution for citric acid was prepared by the addition of ammonium chloride and hydrochloric acid solution as the electrolyte; the solution of common salt was directly polarographed.

Results and Discussion

Experiment A

Organoleptic changes such as off-flavor, color and odor were hardly detectable immediately after irradiation at a dose level of 5.0×10^5r. At a dose of 2.0×10^6r their changes, however, were usually observable. For example, the color change of some irradiated samples is illustrated in Figs. 1–4.

In this experiment, swelling of canned mandarin oranges in syrup was observed with an irradiation dose of 2.0×10^6r. It seems that the interaction between metals from the can material and sugar or citric acid in the contents was promoted by gamma irradiation.

As the result of ferroxyl test, the interior surface of the irradiated can was clearly observed as blue color prints on the testing paper as shown in Figs. 5–13. In the illustrated plates, the surrounding black color appearing on the papers shows the cutting parts of the can material. As the results of Table 2 and Figures mentioned above, the interior surface coated with lacquer or C-enamel was effective for protecting the tin-plate from the irradiation damage at a dose level of 2.0×10^6r.

Table 2. Effect of gamma irradiation on the interior coating of various canned foods.

No.	Variety	Irradiation dose (r.)	Interior coating	Evaluation of color detecting		
				Lid plate	Bottom plate	Body plate
1	Boiled Mackerel	Control	E	+ (W)	−	±
2	〃	2.0×10^6	〃	+++ (W)	−	±
3	〃	Control	〃	−	−	±
4	〃	5.0×10^5	〃	−	−	±
5	Seasoned Tuna	Control	F	−	−	−
6	〃	5.0×10^5	〃	−	−	−
7	〃	2.0×10^6	〃	−	±	−
8	Smoked Tuna in oil	Control	F	−	−	−
9	〃	5.0×10^5	〃	−	−	−
10	〃	2.0×10^6	〃	−	−	−
11	Mandarin Orange in syrup	Control	F	−	−	++++ (W)
12	〃	2.0×10^6	〃	−	−	++++ (W)
13	Sweetcorn (creamed)	Control	E	−	−	−
14	〃	2.0×10^6	〃	−	−	−
15	Seasoned Whale	Control	F	±	−	±
16	〃	2.0×10^6	〃	±	±	±
17	Smoked Oyster in oil	Control	W	±	±	+
18	〃	2.0×10^6	〃	±	+	++
19	Boiled Salmon	Control	W	+	+	+
20	〃	2.0×10^6	〃	++	+++	++

E; C-enamel, F: lacquer, W: white (uncoated)
The marks of −, + and ± show the degree of negative, positive and slightly positive color detecting on the test paper respectively.

Experiment B

In the former experiment, it was ascertained that the uncoated can was liable to be injured by gamma irradiation as compared with the interior coated one. On this point, the results of 4 kinds of solution packed in the white cans are shown in Table 3 and Figs. 14-17. They indicated that sugar and common salt were extremely vigorous with irradiation damage to the white cans, namely the uncoated cans.

In this experiment, a precipitate of irony rust was formed in the can packed

Table 3. Effect of gamma irradiation on the interior coating of pocket typed cans packed with the solution of food constituents.

No.	Variety	Irradiation dose (r.)	Interior coating	Evaluation of color detecting		
				Lid plate	Bottom plate	Body plate
1	0.3% citric acid	Control	W	++	+	−
2	〃	5.0×10^5	〃	+	+	−
3	〃	2.0×10^6	〃	+	+	±
4	17.5% Sugar (glucose)	Control	W	−	+	−
5	〃	5.0×10^5	〃	++	+	−
6	〃	2.0×10^6	〃	++	+	+
7	Soy sauce	Control	W	++	++	±
8	〃	5.0×10^5	〃	++	++	±
9	〃	2.0×10^6	〃	++	+++	±
10	2% Common salt (sodium chloride)	Control	W	−	±	−
11	〃	5.0×10^5	〃	±	+	−
12	〃	2.0×10^6	〃	+++	+	±
13	17.5% Sugar (glucose)	Control	F	−	−	±
14	〃	2.0×10^6	〃	±	−	±
15	〃	Control	W	±	±	±
16	〃	2.0×10^6	〃	++	+	+
17	5% Common salt (sodium chloride)	Control	F	−	−	±
18	〃	2.0×10^6	〃	−	−	±
19	〃	Control	W	+	+	±
20	〃	2.0×10^6	〃	++	+++	±
21	1% citric acid	Control	F	−	−	−
22	〃	2.0×10^6	〃	−	−	−
23	〃	Control	W	++	+	−
24	〃	2.0×10^6	〃	++	+	+

The marks of F, W, −, + and ± were explained in Table 2.

with the solution of common salt and the amount of precipitate varied directly with the irradiation dosage. On this phenomenon, it is considered that the rusty substance is not probably identical with iron and ferrous or ferric compounds from the negative result of the qualitative test for iron metals.

The difference of irradiation effect between those solutions and can materials coated or uncoated is shown in Table 3. The results indicate that the tin-plate of a white can was easily damaged by an irradiation dose of 2.0×10^6r in both cases of the solutions of sugar and common salt as shown in Table 3 and Figs. 18–21. It is concluded that the interior coating of lacquer or C-enamel was effective to prevent the irradiation damage in the present studies. Moreover, the rich of common salt or citric acid was corrosive compared with the diluted solution.

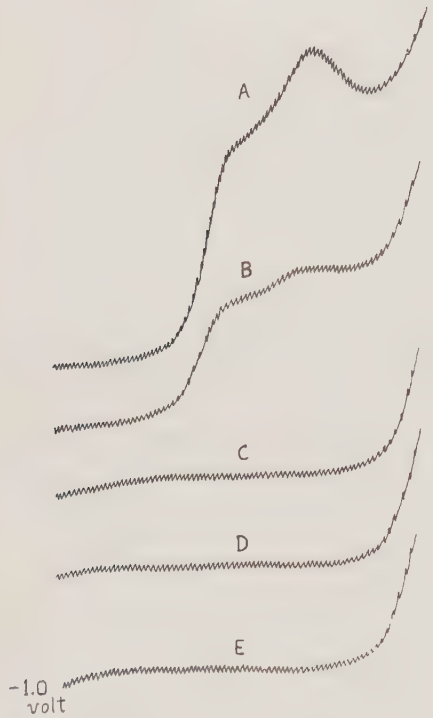

Fig. 22. Polarographic observation on the solution of 5% common salt irradiated under several conditions.

A: White can, Packed in the air, Irradiation of 2.0×10^6r.
B: White can, Packed after exhausting, Irradiation of 2.0×10^6r.
C: Lacquer coated can, Packed after exhausting, Irradiation of 2.0×10^6r.
D: White can, Packed after exhausting, Unirradiated control.
E: White can, Packed with water instead of 5% common salt in the air, Irradiation of 2.0×10^6r.

Experiment C

Metal groups of tin and iron were assayed and found especially abundant in canned mandarin oranges. The amounts of the metals isolated from the can were so small that it was difficult to determine the above-mentioned metals by polarography. It was found that well defined polarographic waves was obtained as shown in Figs. 22 and 23.

In this case, the heights of the polarographic waves increased according as the irradiation dose increased. The effect of irradiation between the white can and the lacquer-coated can was distinctly shown by polarography, especially with solutions of 5 per cent common salt packed under several conditions, and with 1 per cent citric acid.

In Fig. 23, the polarographic waves of tin was determined by the half-wave potential using a standard solution of tin, but in Fig. 22 unknown polarographic waves of A and B were obtained.

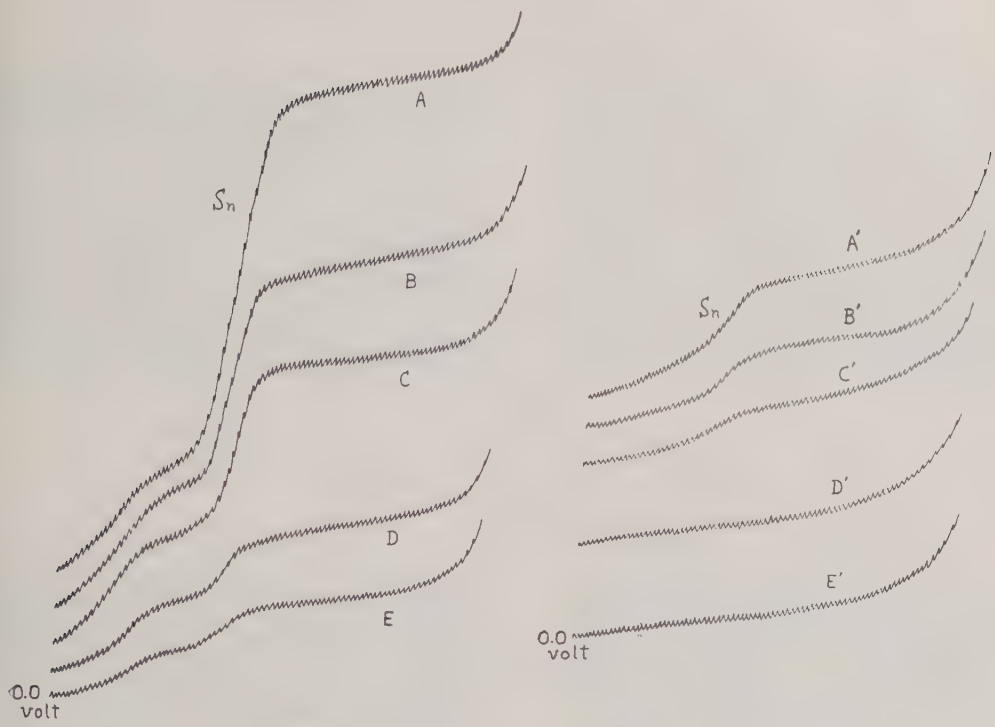

Fig. 23. Polarographic observation on the solution of 1% citric acid irradiated under several conditions.

A, A′: White (A), Lacquer (A′), Irradiation of 2.0×10^6r.
B, B′: White (B), Lacquer (B′), Irradiation of 5.0×10^5r.
C, C′: White (C), Lacquer (C′), Unirradiated control.
Those were prepared by diluting 4 parts of sample solution to one part of NH_4Cl and HCl as the electrolyte for analysis.
D, D′: White (D), Lacquer (D′), Irradiation of 2.0×10^6r.
E, E′: White (E), Lacquer (E′), Unirradiated control.
Those were prepared by diluting of 1:1 as described above.

In the further polarographic observations of metals of irradiated canned foods may be conducted and systematic studies may be expected.

Summary

The effect of gamma-ray irradiation on various canned foods (8 kinds) and their can materials was examined by organoleptic observations, ferroxyl tests, and polarographic determinations.

Off-flavor, color and odor of the canned foods and can damage were scarcely ascertainable with a dosage of $50.\times10^5$r.

The difference in irradiation effects on interiorly coated and uncoated cans at the dose level of 2.0×10^6r was easily shown by the ferroxyl test and the polarographic estimation.

Of all constituents, common salt, sugar and citric acid were unfavourable for irradiation on white can materials.

It seems that canning combined with irradiation will probably be suitable for use in pasteurization of foods by gamma-ray with a dose of 5.0×10^5r and for sterilization with a dose level of 2.0×10^6r. At these irradiation levels there appears to be no damage to the interior coating of the can.

Acknowledgement

The authors wish to express their appreciation to Mr. J. Senō and the staffs of the Research Laboratory of Japan Canners Association for their kind advice in the preparation of this experiment.

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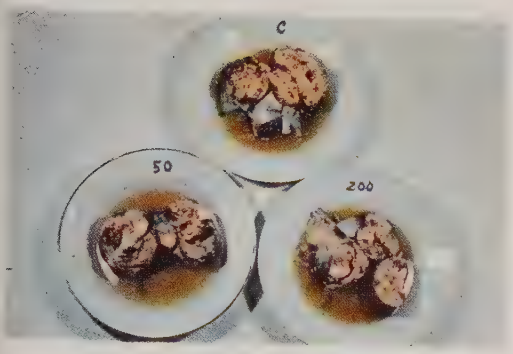


Fig. 1

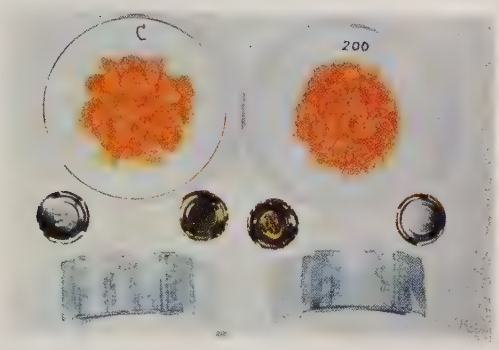


Fig. 3

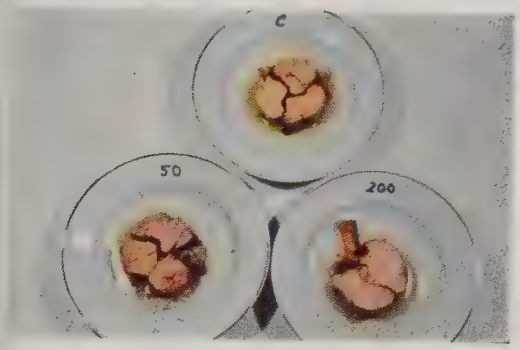


Fig. 2

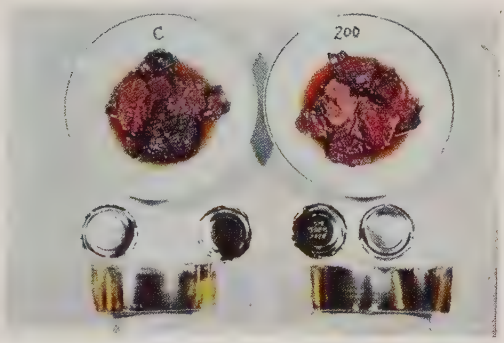


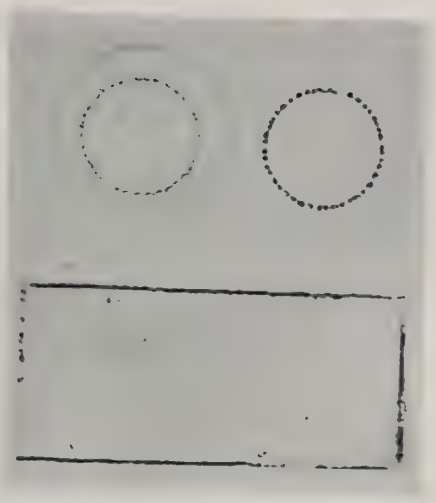
Fig. 4

PLATE V

Figs. 1 to 4 show the color change of irradiated samples and interior surface of cans. C: Unirradiated control, 50: Irradiation of 5.0×10^5r. 200: Irradiation of 2.0×10^6r.

Fig 1. Boiled mackerel
Fig. 2. Smoked tuna in oil
Fig. 3. Mandarin orange in syrup
Fig. 4. Seasoned whale

Notes: Plates V to X illustrate the influences of gamma irradiation on the interior surface of cans under various conditions and the results by ferroxyl test. In those plates the left part of the two round papers in each division shows the color printing pattern of a lid plate of the can, the right shows a bottom-plate and the square part is a body-plate. In Fig. 5 the left and right prints are in the reverse order.



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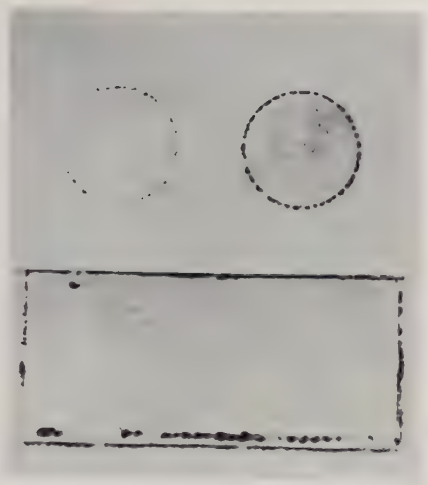
A

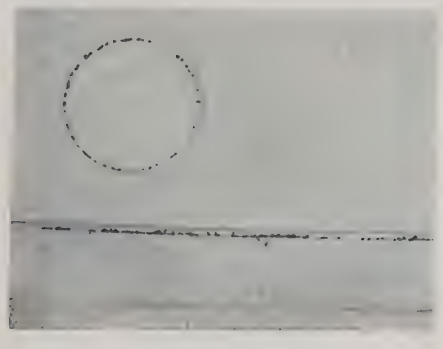


B

6

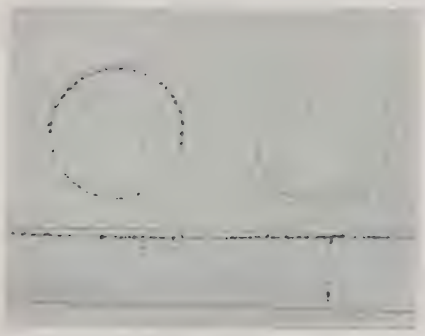
A

B



7

A



B

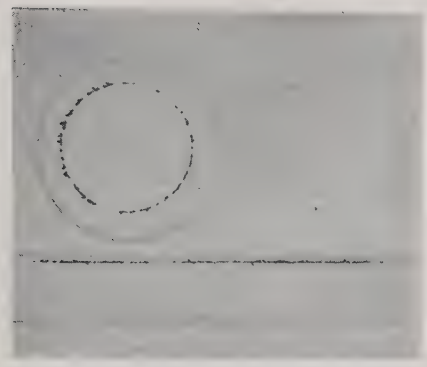
PLATE VI

Figs. 5 to 7 correspond to Nos. 1 to 5 and 7 in Table 2 respectively.

Fig. 5. Boiled mackerel in a partially coated can.
A: Unirradiated control, B: Irradiation of 2.0×10^6r.

Fig. 6. Boiled mackerel in a coated can.
A: Unirradiated control, B: Irradiation of 5.0×10^5r.

Fig. 7. Seasoned tuna in a coated can.
A: Unirradiated control, B: Irradiation of 2.0×10^6r.



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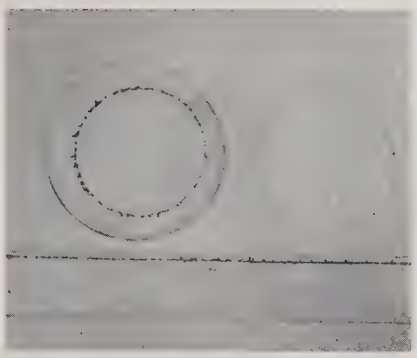
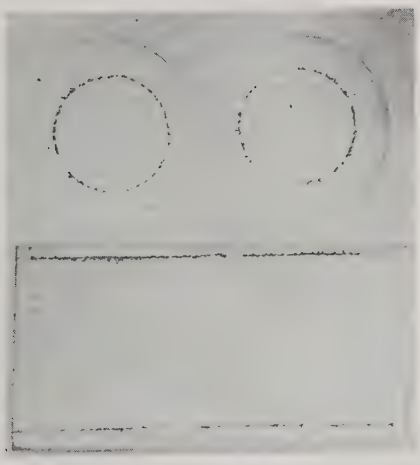


A B

9

A B



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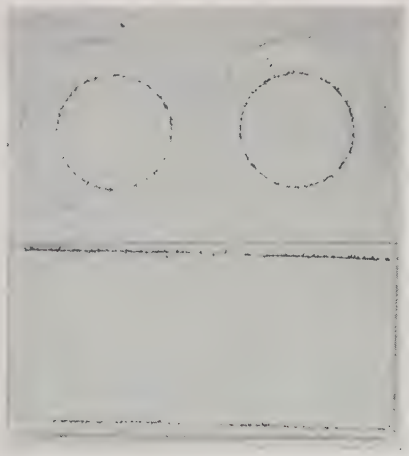


A B

PLATE VII

Figs. 8 to 10 correspond to Nos. 8, 10, 11, 12, 13 and 14 in Table 2 respectively.
A: Unirradiated control, B: Irradiation of 2.0×10^6r.
Fig. 8. Smoked tuna in oil in a coated can.
Fig. 9. Mandarin orange in syrup in a partially coated can.
Fig. 10. Sweetcorn in a coated can.

11

A

B

12

A

B

13

A

B

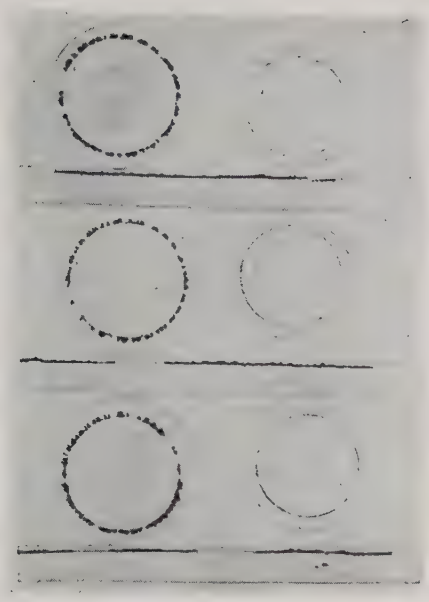
PLATE VIII

Figs. 11 to 13 correspond to Nos. 15 to 20 in Table 2 respectively.
A: Unirradiated control, B: Irradiation of 2.0×10^6r.

Fig. 11. Seasoned whale in a coated can.

Fig. 12. Smoked oyster in oil in a white can.

Fig. 13. Boiled salmon in a white can.

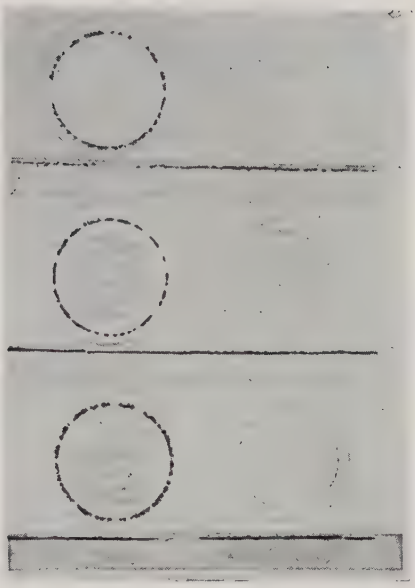


14

A

B

C



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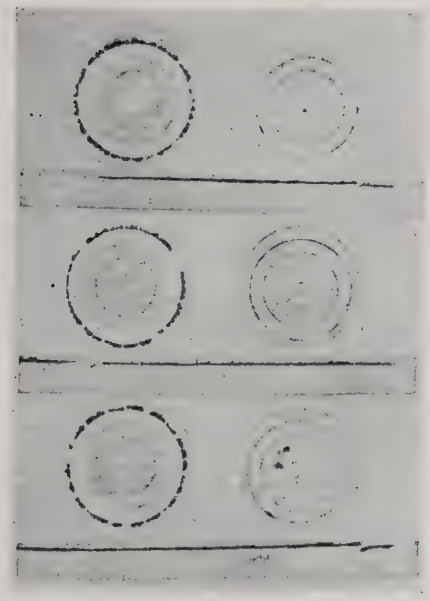
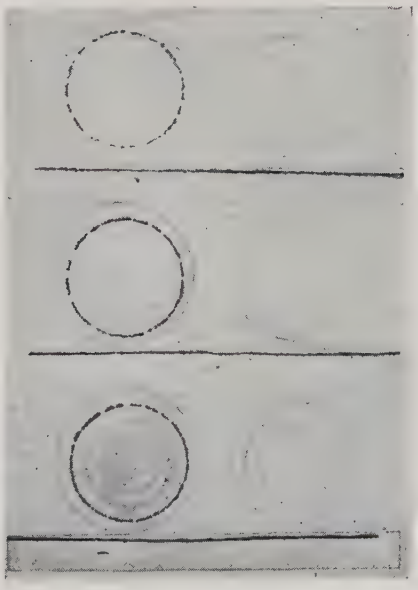


16

A

B

C



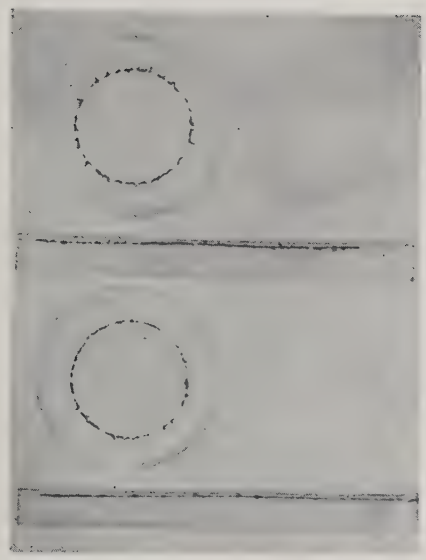
17

PLATE IX

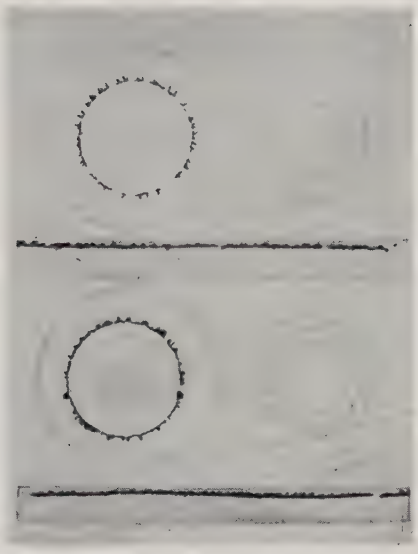
Figs. 14 to 17 correspond to Nos. 1 to 12 in Table 3 respectively.

A: Unirradiated control, B: Irradiation of 5.0×10^5r. C: Irradiation of 2.0×10^6r.
All were packed in a white can.

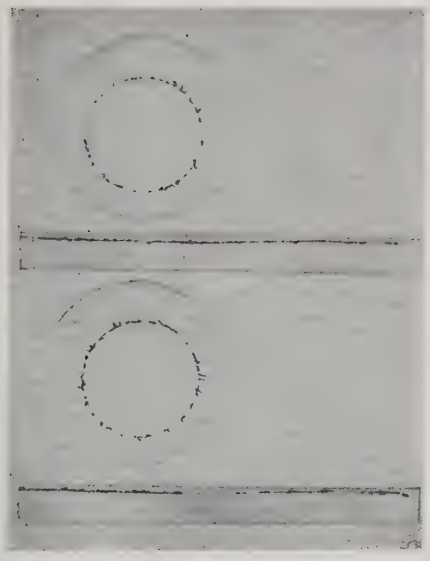
Fig. 14. 0.3% citric acid
Fig. 15. 17.5% sugar
Fig. 16. Soy sauce
Fig. 17. 2% common salt



18



19



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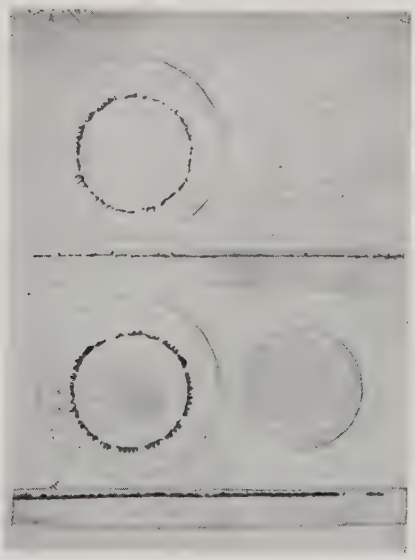

21

PLATE X

Figs. 18 to 21 correspond to Nos. 13 to 20 in Table 3 respectively.
A: Unirradiated control, B: Irradiation of 2.0×10^6r.
Fig. 18. 17.5% sugar in a coated can.
Fig. 19. 17.5% sugar in a white can.
Fig. 20. 5% common salt in a coated can.
Fig. 21. 5% common salt in a white can.

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A NEW SPECIES OF *PORPHYRA* AND ITS *CONCHOCELIS*-PHASE IN NATURE

Akio Miura

From 1957 to 1959 the writer engaged in the investigation of the *Conchocelis*-phase of *Porphyra* in nature at the *Porphyra* cultivating-ground in Tokyo Bay, situated off shore from the Tokyo International Air Port. Through this work, a new species of *Porphyra* has been collected, which grows on the shells of *Mollusca* deposited below the lowest low water mark, but has not as yet been found on other substrata such as bamboo, wood and nets provided for *Porphyra* cultivation. Moreover, the writer has ascertained that the leafy thalli of this species of *Porphyra* originates from the uniserial cell-rows which develop on the vegetative filaments of *Conchocelis* in the shells.

Up to now, other species of *Porphyra* that reproduce leafy thalli immediately from the *Conchocelis*-phase have not been reported. After careful examinations the writer has concluded that this species of *Porphyra* is new to science. The morphological and ecological characteristics of this new species in the *Conchocelis*-phase and leafy-phase are given below.

Porphyra tenuipedalis spec. nov.

Frons membranacea, monostromatica, oblongo-lanceolata, margine undulatis, sinibus gravibus, basi cuneata cum stipite distincto, 8–30 cm longa, 2–9 cm lata, 14–42 μ crassa; colore rutilo vel puniceo; cellulis vegetativis a viso superficiali fere rotundis vel ellipticis quam diametro; spermatia in antheridio 128 (a/4, b/4, c/8), carposporae in sporocarpio 64 (a/2, b/2, c/4). Thallus in stato Conchocelis faciens maculam puniceam a superficie conchae, filis pinnate ramosis; ramis moniliformis, articulis globosis ca. 12–18 μ diametro.

Japanese name. Kaigara-amanori (n. n.)

Hab. Haneda, Daishigawara., Tokyo Bay.

Frond oblong or lanceolate, 8–30 cm long, 2–9 cm broad, cuneate base with conspicuous stipe, margin entire and slightly undulate, foldings deeply; monostromatic, 14–42 μ thick; vegetative cells in surface view usually round or elliptic, irregularly arranged, in cross section long elliptic, twice or three times as long as broad, surface jelly thin, 3–4 μ thick; lower cells oblongcapitate projecting rhizoids; chromatophore single, stellate; color of frond blackish purple when living, in herbarium fire red or ceries; thallus monoecious, antheridia and cystocarps intermixed in a marginal zone, presenting fine splashed pattern, each antheridia containing 128 antherozoids, dividing formula 128 (a/4, b/4, c/8), cystocarps each containing 16 carpospores, dividing formula 16 (a/2, b/2, c/4); growths in *Conchocelis*-phase appearing as pink colored spots on the surface of shells, lateral branches of filament inflating in globular at terminal, junctions and intermediate portions.

The Leafy-phase

The present new species of *Porphyra* are found on dead bivalve shells which were deposited below lowest low water, but has not been found on any other substrata such as the apparatus for *Porphyra* cultivation, which is constructed with nets and bamboo poles. The young, minute plants of the species occur in abundance on the surface of the shells at the beginning of November. From January to February, these plants are luxuariant and in March gradually disappear. The lanceolata or oblong shape of this plant is fairly constant. The frond is conspicuously stipitate at the base, the stipe is slender, 2–3 mm in length. The observations of the manner of development of the leafy thalli will be referred to in descriptions on the *Conchocelis*-phase. The plant is monostromatic in the vegetative portions, however, portions composed of two or more layers of cells frequently occur in the sections of a thallus. In the portion of the thallus composing of two or more layers of cells, the cells are of various sizes and irregularly arranged. Therefore, it is probable that these portions are gall structures. The thickness of the vegetative portion varies with the parts of the thallus, *i.e.*, that of the middle part may be 42 μ and that of the marginal part may be 14 μ in thickness.

The plant is distinctly monoecious, but has a protandry tendency, so that it often appears to do dioecious when in mature. The antheridial and carposporangial patches are intermixed with each others, the patches are so narrow that they form very fine splashed patterns along the margin of the thallus. Vegetative cells are frequently found among the sporocarps. The marginal portions, from which reproductive cells have been liberated, are minutly idented. In cross section, the sporocarps are long ellipsoids, two and one half times as high as broad, trichogyneous processes are found at both sides. At first, a sporocarp undergoes a transverse division parallel to the surface of the thallus, giving rise to two parts, the upper and lower. Each part then undergoes a cruciate division perpendicular to the surface of the thallus. The sporocarp is now divided into eight parts, each of which divides further by a transverse division, so that the whole sporocarp subsequently consists of sixteen carpospores arranged in four tiers of four each. In the course of the division of the sporocarps, the directions of the divisions are not strictly parallel or perpendicular to the surface view of the thallus, but they are more or less obliquely curved. As a result, the carpospores in a carposporangium often are of different shapes and sizes, and their arrangement sometimes is irregular, so that carpospores are frequently number from four to eight in the surface view of the carposporangium. It would appear that the oblique curving of the division directions of the sporocarps is related to the ellptical shape of the sporocarps. Such a feature of the carposporangia makes it difficult to determine the dividing formula of the sporocarp; the division mode of the sporocarp of this species may be referred to the formula 16 (a/2, b/2, c/4). Each antheridia contains 128 spermatia after having divided according to the formula 128 (a/4, b/4, c/8); the mode of division of antheridium is regular and spermatia in a antheridium are arranged eight tiers of sixteen each.

Considering only the dividing formula of reproductive cells, the present species belongs, in so far as Japanese species of *Porphyra* are concerned, to the

type *Porphyra okamurai* Ueda, *P. dentata* Kjellm., *P. seriata* Kjellm. and *P. crassa* Ueda. The manner of the reproductive cell division of this species is peculiar, and many aspects of its morphology and ecology are quite distinct from them, *i.e.*, according to Professor Ueda (1932) and Tanaka (1952), above mentioned species of *Porphyra* grow on rocks in the intertidal zone. Furthermore, *P. okamurai* and *P. dentata* have microscopical spine at the marginal part of thallus and *P. crassa* is dioecious or androdioecious. The present species is also distinguishable from *P. seriata* by outer appearances, and especially by the latter's characteristic antheridial patches presenting a regularly checkered pattern. So the writer puts the present species into the new species of *Porphyra*.

This plant of new species has not been commercialy utilized as marketable *Porphyra*, which is an article of food, the so-called "Nori" of Japan. According to the results of a test undertaken by the Tokyo-To Fisheries Experimental Station, dried *Porphyra* made of the plants of this species has been found inferior quality to that made of plants of other species, especially in required to taste. The utility value of this new species of *Porphyra* has not as yet been established.

The *Conchocelis*-phase

The *Conchocelis*-phase of this species in nature has been investigated in the *Porphyra* cultivating-grounds, *i.e.*, in the shallow water sand-mud bottom of Tokyo Bay. *Porphyra* cultivation takes place from October to April. *Porphyra yezoensis* Ueda is the dominant cultivated species. The specimens of the *Conchocelis*-phase were collected periodically with a drege. Many of the observations described here and many of the photographs reproduced were obtained from living specimens in shells. Preparations for the microscope were made by means of a similar to the microscopical sectioning of minerals.

The monthly average surface water temperature during the year in the area of this investigation are shown as follows:

1958	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
°C	7.9	7.5	10.5	13.8	19.3	23.0	25.5	26.9	24.5	17.4	14.0	11.1

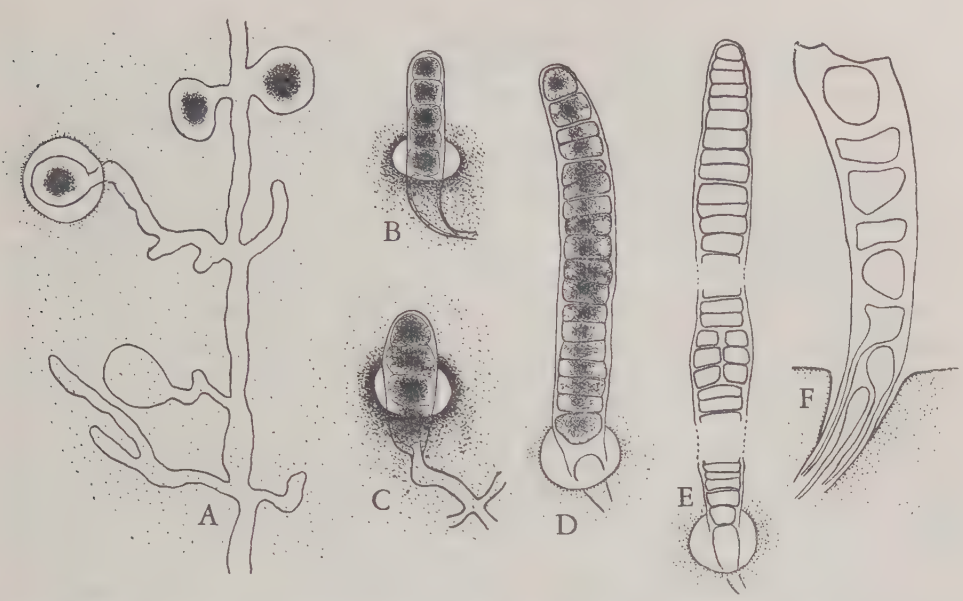
(from the data of survey by the Tokyo-To Fisheries Experimental Station)

The *Conhcocelis* growths of this species grow in the calcareous matrix of various dead bivalve shells. These *Conchocelis* growths are recognized on the shells as pink colored spots of various sizes. The *Conchocelis* growths, which consist of filamentous cells 2–4 μ in diameter, show entangled pinnately branching features. The septa between the filamentous cells are obscure. The plastids in the filamentous cells are linear and parietal. The cell is usually filled up with a plastid, presenting a conspicous pink color. The filament of the *Conhcocelis* growth grows in a straight line as compared with the lateral branch of the filamemt. The latter filaments are usually inflated in globular nodules here and there. The inflated portions are 12-18μ in diameter and contain a plastid which becomes reticulate. The inflated portions correspond quite well with spindle-shaped cells and inflated cells named by Rosenvinge (1931). Such features of the lateraly branched filament is one of the morphological characteristics of the *Conchocelis*-phase of the present species.

From November to March, but especially in November, the uniserial cell-rows, which consist of 2–4 quadrate cells with a star-shaped plastid in each cell, are found in the shells. The development of a uniserial cell-raw is initiated by the formation of a spherical cell at the end or lateral of the vegetative filament. Spherical shells, which are initials of the uniserial cell-rows, are 20–30 μ in diameter and have a deep colored plastid localized in their central portion. These initial cells of the uniserial cell-rows are not without resemblance to the globular inflated portions of a vegetative filament, but they are distinguishable by the difference of the originating position, sizes of cells and the shapes of plastids. Therefore, it is impossible to think that the former have resulted from the latter. When the uniserial cell-rows have grown to 3–4 cells, apical cells are exposed at the surface of the shell through cylindrical openings which are formed to surround the uniserial cell-rows in a calcareous layer of the shell. The diameter of the openings is about 18 μ and the depth of them is nearly 30 μ. The uniserial cell-row is connected by a short vegetative filament with the ordinary vegetative filament. So the uniserial cell-rows look like stipitate. The apical cells of the uniserial cell-rows, which have been exposed at the surface of the shell, divide transversely and grow into young plants. The young plants grow to keep uniserial form and they are uniserialy composed of 30–50 cells. The appearance of them look like fronds of *Bangia*. Subsequently, these young plants undergo perpendicular divisions in the intercalary cells and grow finally into leafy thalli. The lower basal portion of the young plant is observed in the calcareous layer of the shell and rhizoids projecting from cells of the basal portion have been observed to grow toward the inside of the shell. It is probable that a matured, leafy thallus having a conspicuous stipe at the base develops along such a growing course as outlined above. As young plants grow up, the connections laid between the vegetative filaments of the *Conchocelis* growth and the leafy young plants become gradually obscure. On the surface of a shell obtained in November, young plants of various sizes were seen to be growing in clusters, while in the calcareous layer of the same shell a number of uniserial cell-rows were observed by microscope through the calcareous layer.

The uniserial cell-rows seem to be homologous structure to the fertile cell-rows as described in detail by DREW (1954). That is why the former never show a divergency but closely correspond to the latter in the manner of their development and in the metamorphosis of a plastid contained in their cells. The uniserial cell-rows occurring in the *Conchocelis*-phase of this species grew into leafy thalli, while the fertile cell-rows occurring in that of *Porphyra umbilicalis* (L.) KÜTZ. f. *laciniata* (LIGHTF.) J. AG., which were investigated by DREW (1954), did not reproduce leafy thalli in any way.

On the other hand, in the *Conchocelis*-phase of the following species the sporangia were formed on the vegetative filament and spores liberated from them developed into leafy thalli: *P. tenera* KJELLM., *P. suborbiculata* KJELLM., *P. umbilicalis* (L.) J. AG. prox., and *P. pseudolinealis* UEDA, from Japan, KUROGI (1953); *P. tenera* KJELLM., from Tsingtao, China, TSENG and CHANG (1953); *P. capensis* KÜTZ., from Cape Town, GRAVES (1955); *P. perforata* J. AG., from California, HOLLENBERG (1958).



Text-fig. A–F. Stages in development of the leafy thallus from the *Conchocelis* filament. A. Initials of uniserial cell-rows with central plastid. B–C. Uniserial cell-rows exposing at surface of shell through opening, showing connection with vegetative filament, and cells with star-shaped plastid. D. Young plant growing in uniserial form, showing each cell with star-shaped plastid. E. Young plant commencing longitudinal cell division in intercalary cells. F. Basal cells of young plant showing projection of rhizoids inside of shell. (Dotted part indicating calcareous layer of shell.)

As ascertained by Ueda (1929, 1937), *Porphyra* usually tends to yield monospores when young, by which leafy thalli propagate repeatedly. However, in the study of the present species the formation and liberation of monospores was not observed either in nature or in the laboratory. Experiments were undertaken several times by placing minute thalli 1–5 mm in length in Petri dishes for a few days, however, the liberation of monospores was not observed. It appears that the present species does not reproduce leafy thalli by means of spores during any phases of its life-history. This species, in fact, appears never to occur any other substrata except on deposited shells. This fact may support to some degree the contention that leafy thalli of this new species are directly issued from the *Conchocelis* filaments without any spores.

Up to now, *Porphyra* exhibiting a life-history as described above have never been reported, but Dangeard (1931) considered that *Porphyra* thalli might develop from buds formed on the vegetative filaments of the *Conchocelis*-phase. His consideration is similar to the life-history of the present species.

The Shells bearing the *Conchocelis*-phase

The *Conchocelis*-phase of the present species of *Porphyra* was found on almost all species of bivalve shells (*Pelecypoda, Mollusca*) which had been de-

posited in the investigation area. Of the various kinds of shells, shells of *Andara subcrenata* (LISCHKE), *Dosinia japonica* (REEVE), *Mactra veneriformis* (REEVE), *Ostrea gigas* THUNBERG were particularly abundant, *Gastropoda* very few. The *Conchocelis*-phase of this species was found with the most frequency in shells of those species which were deposited in the depth range of 0.5–1.5 m.* Shells of *Mytilus edulis* LINNE and *Branchiodontes senhausia* (BENSON) were also abundant, however, the *Conchocelis*-phase of this species has not been found in them. Most of the bivalve shells bearing the *Conchocelis*-phase are disjointed into left and right valves, and calcite in the prismatic layer of the shells is exposed, falling off the periostracum of them. Only the shells of *Ostrea gigas* THUNBERG have been observed alive bearing the *Conchocelis*-phase. The fact that the *Conchocelis* growth was not observed on most living shells may be due to the differences in ecological habitat between the *Conchocelis*-phase and the *Pelecypoda*.

Pink colored spots showing the *Conchocelis* growths of the present species on the surface of shells were always located only on the convex side of bivalve shells. Not only pink colored spots but also leafy thalli originating from the Conchocelis filaments in shells were observed to occur only on the convex side of bivalve shells.

Judging from these observations obtained in nature, the bivalve shells bearing the *Conchocelis*-phase of this species of *Porphyra* are pressumed to have been laid upward the convex side of them, as putting upside-down a cup, for considerable times. However, when such shells were placed upward the concave side for about one month in the laboratory, the pink colored spots appeared on the concave side of the same shells. The presence of the *Conchocelis* growths predominantly on the convex side of bivalve shells may simply reflect the deposition position of the shells. While depositing conditions of bivalve shells may vary according to the shape of the shells, bottom characteristics and water movement, at least in the area of this investigation, it has been interestingly observed that leafy thalli as well as the *Conchocelis* growths of the present species have always occurred on the surface of the convex side of the bivalve shells.

Acknowledgements

The writer is much indebted to the Socio-Economics Society of *Porphyra* Cultivation Development, Tokyo, for financial support. This investigation was made possible by the aid of many staff members of the Tokyo-To Fisheries Experimental Station. The writer is grateful for the facilities given by them. The field work was carried out in co-operation with Mr. S. ITO, staff of Tokyo-To Fisheries Experimental Station, and the writer is indebted to him for his willing help and many suggestions. The writer wishes to express his sincere appreciation to Professor S. UEDA for his kind guidance and encouragement during the course of this work. Appreciation is also due Mr. K. IWAMOTO for the criticism of manuscript and valuable suggestions, and to Mr. Y. UNO for instructions on concholological matters.

* The vertical datum has been taken 1.2 m below mean sea level, and it is nearly the lowest low water (Tide Table Vol. 1 published yearly by Japan Maritime Safety Board, Tokyo).

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PLATE XI

Porphyra tenuipedalis spec. nov.

1. Surface view of vegetative part of frond.
2. Cross-section of marginal vegetative part of frond.
3. Cross-section of middle part of frond.
4. Basal cells projecting rhizoids.

5-7. Surface view of antheridial part of frond, showing successive stages of divisions of antheridia.

8-11. Cross-sections of antheridial parts of frond, showing successive stages of divisions of antheridia.

12. Cross-section of gall structure formed in frond, showing antherozoids which have been formed from cells of gall structure.

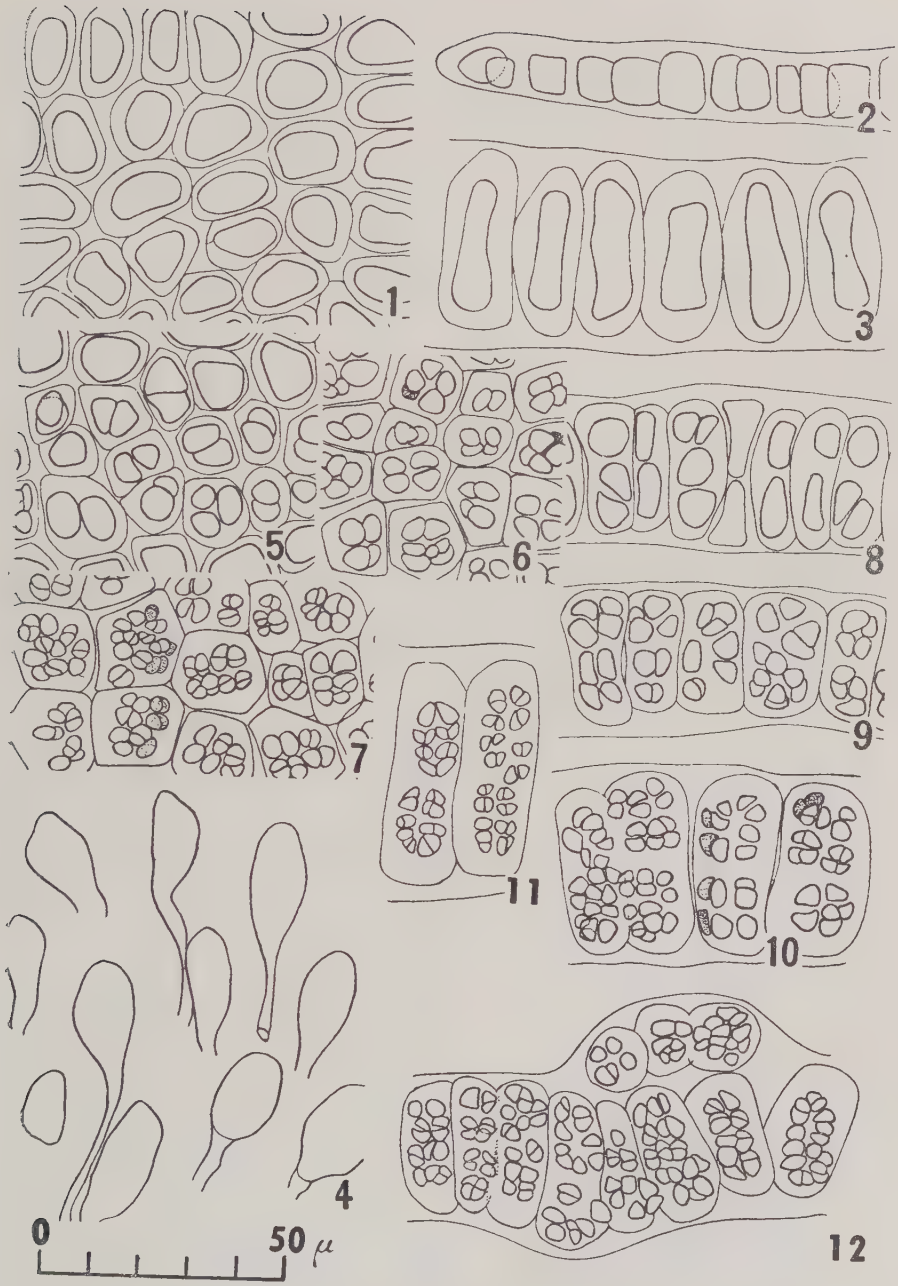
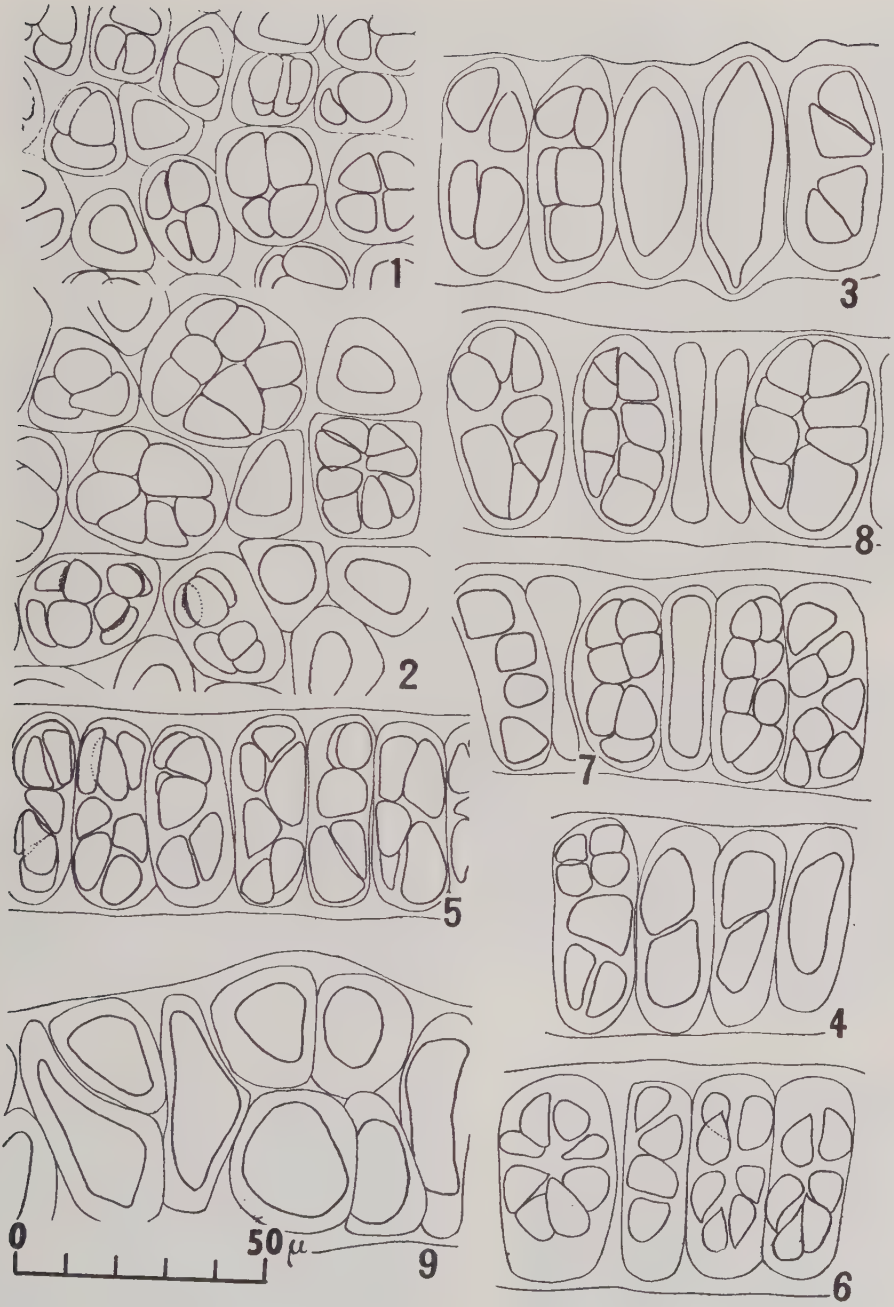

1
2
3
4
5
6
7
8
9
10
11
12
0
50 μ

PLATE XII

Porphyra tenuipdalis spec. nov.

1-2. Surface view of sporocarpic parts of frond.
2. Showing cystocarps in which 8 carpospores are arranged in the surface view.
3-8. Cross-sections of sporocarpic part of frond, showing successive stages of divisions of sporocarps.
9. Cross-section of gall structure formed in vegetative part of frond.


1
2
3
4
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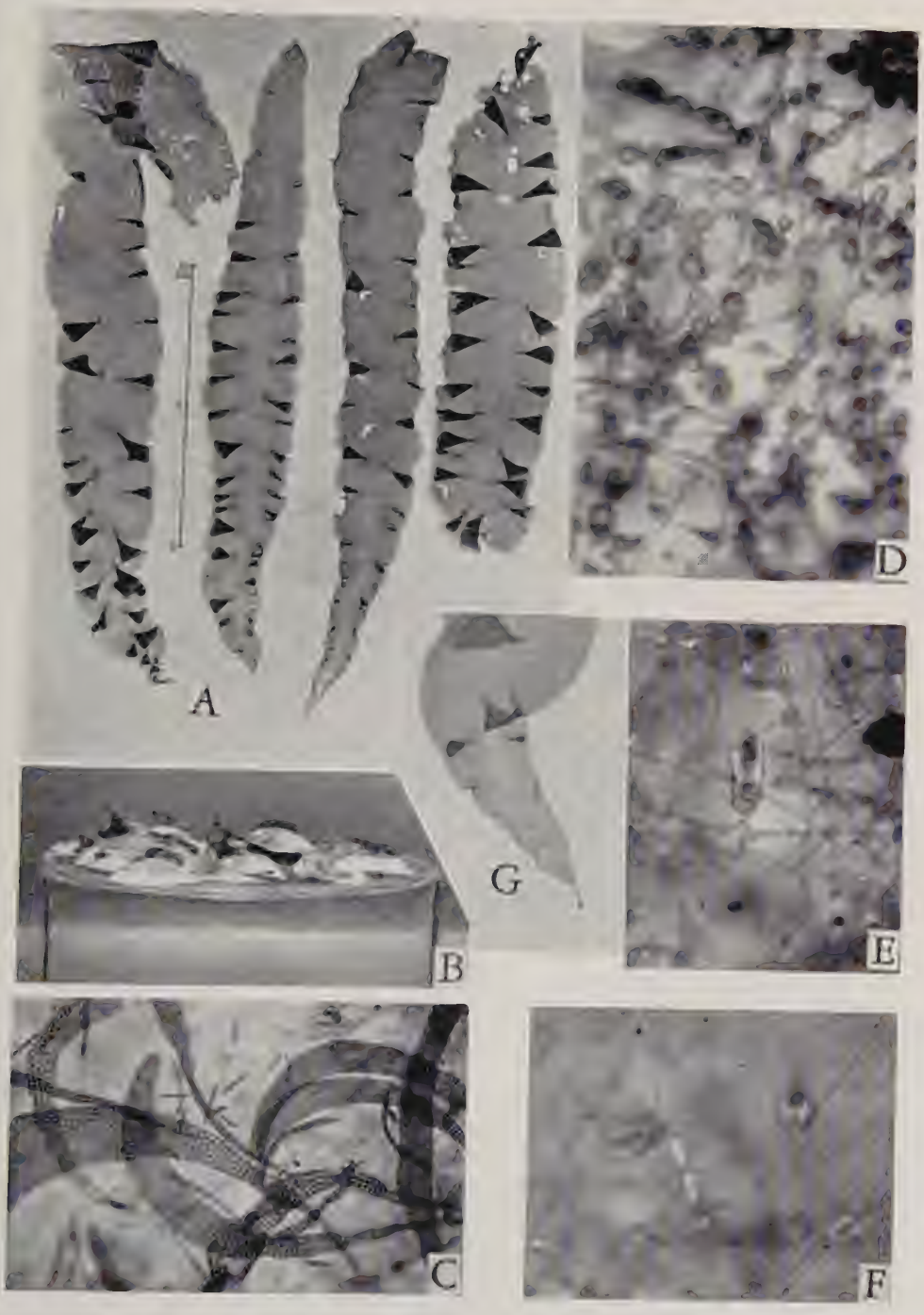
7
8
9
0
50 μ

PLATE XIII

Leafy-phase and *Conchocelis*-phase of *Porphyra tenuipedalis* spec. nov.

A. Type specimens.
B. Young plants growing in cluster at surface of shells, *Venerupis veneriformis*, showing that all young plants grow on convex side of bivalve shells.
C. Various sizes young plants growing at surface of shells, showing slender basal part.
D. Vegetative filaments of Conchocelis-phase showing inflated lateral branch. ×300.
E. Uniserial cell-row composed of four quadrate cells, two upper cells exposed, two lower cells immersed yet, showing connection with vegetative filament. ×250.
F. Basal part of uniserial cell-rows showing connections with vegetative filaments, and openings formed at surface layer of shell. ×250.
G. Stipe of matured thallus, showing conspicuous stipitate feature


A
B
C
D
E
F
G

Journal of the Tokyo University of Fisheries Vol. 47, No. 2, 1961

THE FORM OF FISHING GEAR UNDER WATER—I DEFORMATION OF THE SET—NET (*OTOSHI-AMI*) MEASURED BY A FISH FINDER

Nobuo Hirayama and Katuji Honda

Introduction

The set net (*Otoshi-ami*) is a fishing gear which is usually set in a constant position near the shore, with a lead net run off at a certain angle to the shore. The common Japanese trap net (*Otoshi-ami*) is shown in Figure 1. As seen in Figure 1 the net consists of four main parts: bag-net, funnel-net, heart-net and lead-net. These nets are kept in correct form by buoys connected by ropes to anchors made of sand-bags. Fish trapped by this kind of net include sardine, horse-mackerel, tuna, amber-fish etc.

Since the principle of catching consists essentially in leading fish unawares into the bag-net through the heart-net and funnel-net from the side of the lead net, luring the fish into the net often depends upon the net form. To improve fishing techniques it is as important to determine the deformation of the nets under water as it is to determine the swimming course and behavior of the fish schools. Many observations have been made of parts of the net by diving, underwater photography and model-net experiments; improved net construction has resulted.

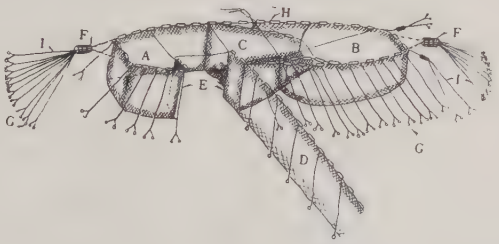


Fig. 1. Common trap net in Japan
A: Heart-net, B: Bag net, C: Funnel net, D: Lead net, E: Entrance of net, F: Float, G: Sand bag, H: Float, I: Sand bag line

In recent years, a fish-finder has been used for measuring the shape of the fishing gear under water and the form of the entire net has been clearly observed in the state of operation.[1)2)3)] However, when using a fish finder with abroad beam, it is difficult to obtain the true shape of the net if either the net surface or ocean bottom is sloping or undulating. This difficulty in determining the net form results from the fact that sounding records taken on paper do not indicate the true depth of the water. Consequently, a formula was determined for the relationship between the recorded and actual depth. The values calculated by

this formula were compared with the relationship between the bottom configuration of a lake surveryed by triangulation before filling with water and the record obtained by echo-sounders after being filled.[4] Since good agreement was obtained between these surveys, it was thought that the formula might be applied in practice, although the method contained some imperfections caused by the net shape and the characteristics of ultrasonic waves.

The present paper is a report on net shapes corrected by the above discussed formula at two fishing grounds, and on the relationship between the deformations of the nets and currents.

Experimental Techniques and Data

Correction of the measured values

The formula mentioned above is defined as follows: In Figure 2, let x and y be rectangular axes, where the vertical axis y is the height from the base line to a net plane, and the horizontal axix x is the position of sounding. The section of net plane may then be shown by $f(x)$. Symbols are defined as follows:

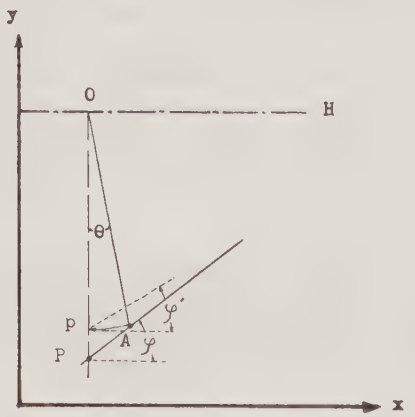


Fig. 2. Model diagram between actual net depth and recording.
O: position of transducer

H: height from base line to water surface
θ: beam angle of half power of ultrasonic
φ: angle of net inclination
φ': angle of inclination recorded on paper
P: position of actual depth of water at point x
p: position of recorded depth of water at point x

In the case of $\varphi > \theta$, on the $\angle OPA$

$$\frac{H-Y}{\cos(\theta-\varphi)} = \frac{H-y}{\cos\varphi}$$

where $h = H-Y$ and $h' = H-y$. Both h and h' are depth from water line respec-

tively.

Thus we obtain from the above equation (1)

$$h=h'\ (\cos\theta-\sin\theta\tan\varphi) \tag{2}$$

where φ is unknown.

When $d\varphi/dx \doteqdot 0$ *i. e.*, when the angle (φ) is gradually increasing, the relationship between φ and φ' is represented approximately,

$$\tan\varphi=\frac{\cos\theta\ \tan\varphi'}{1-\tan\varphi'\sin\theta} \tag{3}$$

From above equations (2) and (3), the following equation is obtained

$$h/h'=\cos\theta+\sin\theta\frac{\tan\varphi'\ \cos\theta}{1-\sin\theta\ \tan\varphi'}$$

$$=\frac{\cos\theta}{1-\sin\theta\ \tan\varphi'} \tag{4}$$

Table 1. Calculation of h/h'

θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$	θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$
2°	2°	1.00061	3°	2°	—
	3	1.00122		3	1.00138
	5	1.00245		5	1.00323
	10	1.00557		10	1.00794
	20	1.01224		20	1.01803
	30	1.01994		30	1.02975
	40	1.02954		40	1.04276
	50	1.04276		50	1.06507
	60	1.06368		60	1.09819
	70	1.10537		70	1.16635
	80	1.24601		80	1.42019
	85	1.66263		85	2.48567
θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$	θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$
5°	5°	1.00384	8°	8°	1.01003
	10	1.01174		10	1.01518
	20	1.02883		20	1.04311
	30	1.04898		30	1.07679
	40	1.07480		40	1.12122
	50	1.11167		50	1.18718
	60	1.17333		60	1.30480
	70	1.30987		70	1.60334
	80	1.96997		80	4.69935
	85	26.4860		85	—
θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$	θ	φ'	$\cos\theta/(1-\tan\varphi'\sin\theta)$
10°	10°	1.01592	20°	10°	—
	20	1.05125		20	1.07330
	30	1.09455		30	1.17090
	40	1.15278		40	1.31792
	50	1.24181		50	1.58630
	60	1.40844		60	2.30548
	70	1.88338		70	15.5834
	80	64.8798		80	—

As the angle θ has 2°, 3°, 5°, 10° and 20°, relation between h/h' and φ' is shown in Table 1 and Figure 3.

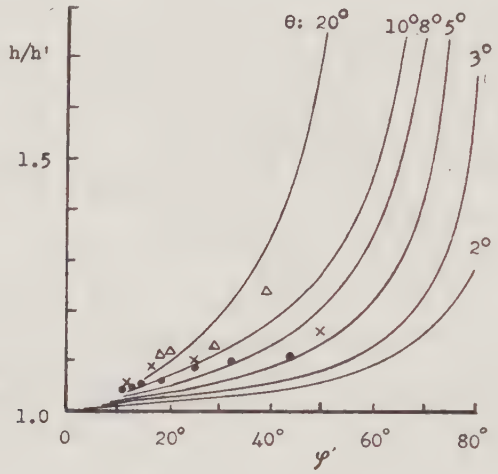


Fig. 3. $h/h'-\varphi'$ curve
Marks show the values which were estimated by Hashimoto's experiment
●: $\theta=5°$
×: $\theta=7.5°$
△: $\theta=16°$

The values calculated from the above equation were compared with the results obtained by Hashimoto and Nishimura[4] who compared the acutal shape of a lake with the record obtained by a fish-finder (Figure 3).

As seen in Figure 3, using $\theta=5°$ the values observed are about 3% larger than the calculated values; the difference in results using $\theta=7.5°$ or 16° seem to be very insignificant.

Observation and Results

The observations were carried out on two set nets, one in Kokabe, Iwate Pref. and the other in Nadakiri, Chiba Pref. The characteristics of the fish-finder used in the present work are as follows: frequency 200 kc, beam angle at half power 3°, dimension of transducer diameter 17 cm., sounding range 0—200 m. and liner recording type. In the present experiments, the main part of the fish-finder was set amidships and the transducer was rigged over the boat's side. The boat ran on the courses as shown in Figures 4 and 5 with constant speed, with as little rolling as possible. In the calculations the parameter θ was obtained by adding the beam angle at half power to a rolling angle of about 2° caused by rowing the small boat. Consequently an angle (θ) of 5 degrees was used in the calculations. The results obtained are shown in Figures 4 and 5. From these Figures, the corrected net form is seen to be somewhat more rounded than the recorded form, especially in cross section.

The work of measurement at the Kokabe fishing ground was performed

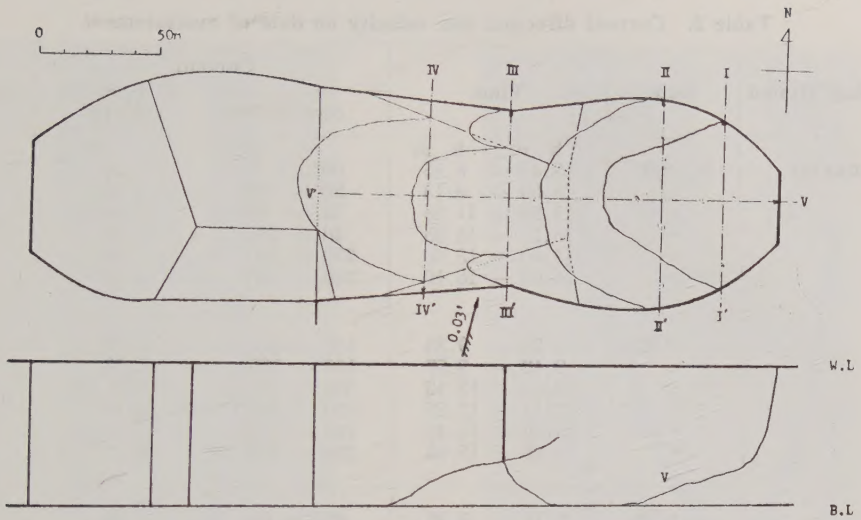


Fig. 4. Schematic diagram of net deformation measured at Kokabe. Arrow mark shows current velocity and direction. I—V show the courses of measurement.

between 0640 and 0800 hours on 20th of Dec. 1959. The sea condition was very calm and a current velocity of 0.03 mile/hour to the northeast was measured by drift-board. As shown Figure 4, it was found that the net form on the whole was maintained, although slight deformation occurred. The netting thread material was made of saran 300 d 3/30—3/51 and the mesh size was from 3 to 5 cm.

The measurements at the Nadakiri fishing ground were conducted on 21—

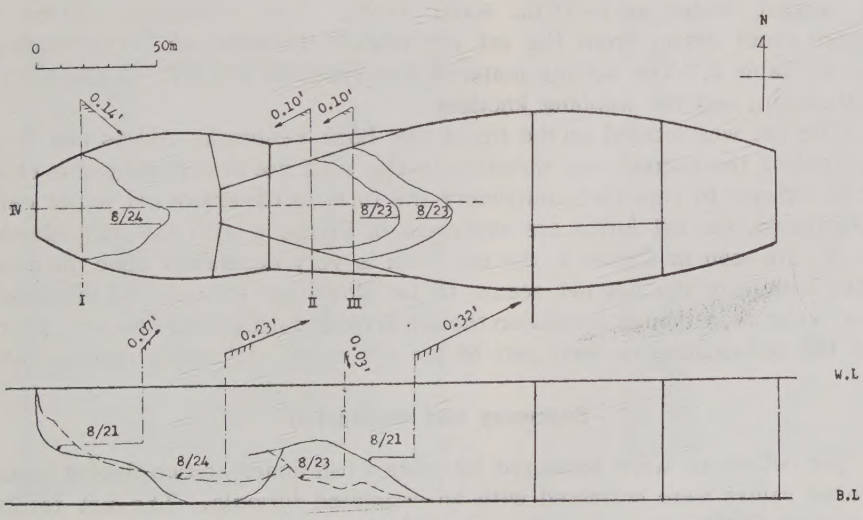


Fig. 5. Schematic diagram of the net deformation measured at Nadakiri. Arrow marks show the estimated current velocity and direction in the measurement. I—IV show the course of measurement. Numerals associated with lines show date of measurement.

Table 2. Current direction and velocity on date of measurement

Fishing ground	Date	Time	Current		Depth*)
			direction	velocity	
		h m h m		kt	
NADAKIRI	34. 8/21	8.45 — 8.55	60°	0.36	5m.
	〃	9.03 — 9.13	50 — 60	0.32	
	〃	11.25 — 11.35	34 — 35	0.06	
	〃	15.25 — 15.35	40 — 280	0.06	
	〃	15.40 — 15.50	270 — 290	0.33	
	〃	16.00 — 16.10	280 — 290	0.34	
	8/23	9.23 — 9.33	160 — 270	0.09	10m
	〃	9.42 — 9.57	160 — 180	0.03	
	〃	12.02 — 12.12	300 — 310	0.16	
	〃	12.17 — 12.27	320 — 340	0.19	
	〃	15.30 — 15.40	240 — 250	0.23	
	〃	15.45 — 15.55	220 — 250	0.25	
	8/24	9.15 — 9.25	40 — 60	0.22	5m.
	〃	9.30 — 9.40	40 — 80	0.21	
	〃	12.20 — 12.30	190 — 280	0.07	
	〃	12.40 — 12.50	230 — 280	0.09	
KOKABE	34. 12/20	6.30 — 6.31	N/E	0.03	1m.

*) Depth of current metre.

24 of Aug. 1959 under calm sea conditions. The techniques were similar to those used at Kobabe. The current velocity and direction were measured by an Ekman-Merz current metre at 5—10 m. water depth. The measuring stations were separated about 200 m. from the set net toward the open sea. The results are shown in Table 2. The netting material was cremona 20S 3/72—3/120, the mesh sizes 9–20 cm., and the webbing knotless.

The net was located as the tip of the Bôsô Peninsula and as can be seen from Table 2 the current and direction in this area are always subject to change. As it is difficult to construct completely the form of the entire net under definite sea conditions, the net forms are expressed in Figure 5 with the data shown in Table 2. As seen in Figure 5, the net form is very dependent upon the current, and the bottom of the bag-net seems to be blown up by only 0.2 mile/hour of current velocity, although it rests on the sea bottom during slack water. Figure 5 shows the deformation of each part of the net under various current conditions.

Summary and conclusion

Set net forms were measured by using a fish-finder at two fishing grounds; measured values were corrected with an estimated formula. The net forms recorded were slightly shallower than the actual ones, and the corrected net form was somewhat rounded compared to that of the recorded form. As the net shapes are clearly dependent upon the current, it is important that current direction and velocity be observed in conjunction with measuring the net forms.

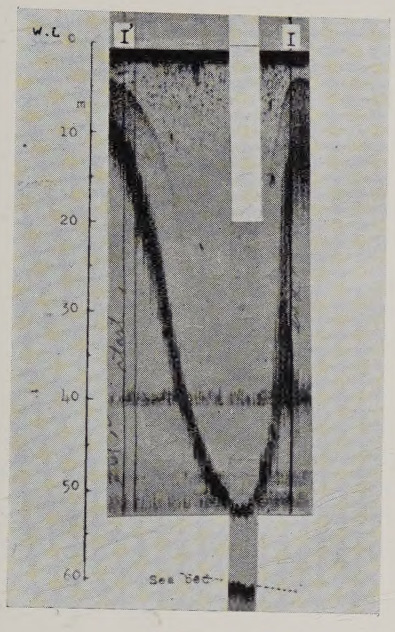


Plate 1

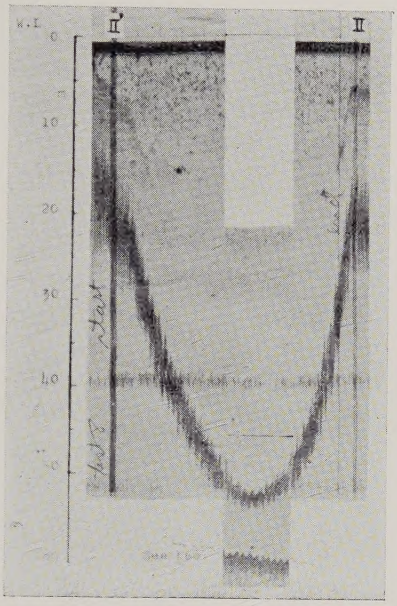


Plate 2

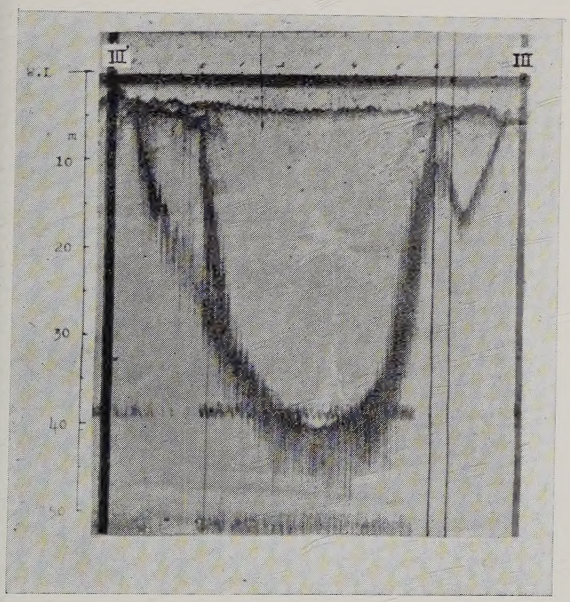


Plate 3

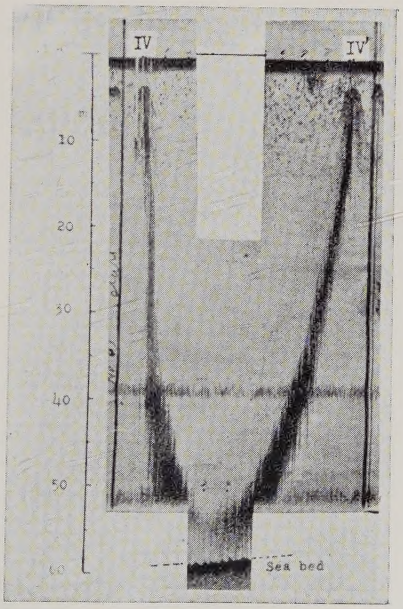


Plate 4

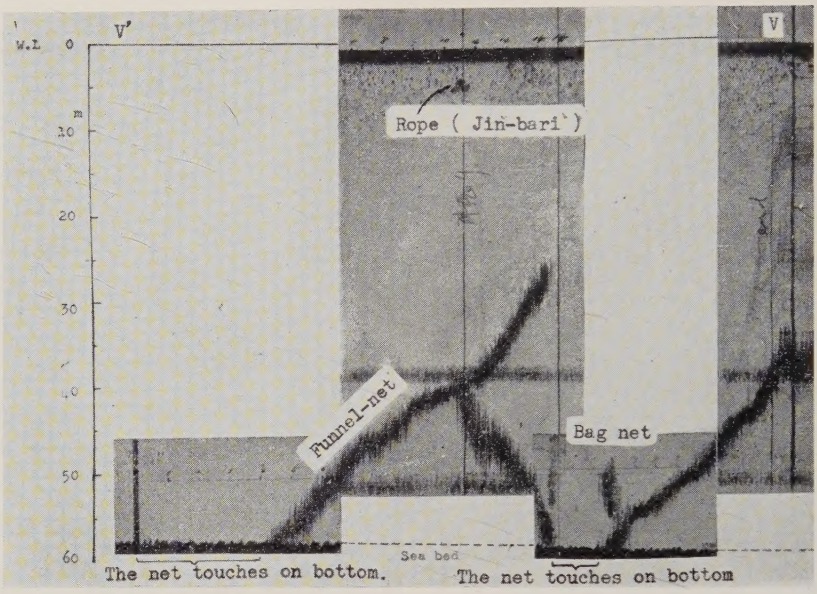


Plate 5

Fig. 6. Records measured by a fish-finder at Kokabe.
Plate 1 Section I
〃 2 〃 II
〃 3 〃 III
〃 4 〃 IV
〃 5 〃 V
(see Fig. 4)

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